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EPA Region 5 Records Ctr.



200553

March 11, 1991

Ms. Linda Kern
Remedial Project Manager
U.S. Environmental Protection Agency Region 5
230 South Dearborn Street
Chicago, IL 60604

**Re: Final Radiochemical Ground-Water Modeling Report
Industrial Excess Landfill, Uniontown, Ohio
Work Assignment No. 21-5NW2, Contract No. 68-W8-0084**

Dear Linda:

PRC Environmental Management, Inc. is enclosing for your review five copies of the Final Report on the Probability of Detection of Hypothetical Radiochemical Contamination of Groundwater at the Industrial Excess Landfill, Uniontown, Ohio.

This report represents a compilation of information and data contributed by Jim Benetti, Air and Radiation Division, EPA Region 5; Dan Ashenberg and Dave Donohue, PRC Helena; A.K. Singh, EPA Environmental Monitoring Systems Laboratory (EMSL), Las Vegas, Nevada; and Jeff Ross, PRC Seattle. The Draft Report was reviewed internally at PRC and by all the parties involved, and review comments have been incorporated into this document. A few statements concerning health risks has been added and should be reviewed by Jim Benetti.

Due to hypothetical nature of the study, the PLUME modeling results are estimates that have a fairly high degree of uncertainty. Based on the assumptions made concerning the source location, these results are nonetheless conservative, and should result in minimum probabilities of detection. The low activities of the radiochemical compounds modeled also indicate that the sources modeled are not of health concern. Jim Benetti may want to expand on this aspect of the results and combine it with previous PRESTO code modeling.

If you have any questions, please call Jerry McLane at 312/856-8700 or Jeff Ross at 206/624-2692.

Sincerely,

Majid A. Chaudhry, Ph.D., P.E.
Project Manager

enclosure

cc: Carl Norman, PO, EPA Region 5 (letter only)
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Dan Ashenberg, PRC
Jerry McLane, PRC
Jeff Ross, PRC

**FINAL REPORT ON THE
PROBABILITY OF DETECTION OF
HYPOTHETICAL RADIOCHEMICAL
CONTAMINATION OF GROUNDWATER
AT THE INDUSTRIAL EXCESS LANDFILL**

UNIONTOWN, OHIO

Prepared For

**U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Waste Programs Enforcement
Washington, D.C. 20460**

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1.0 INTRODUCTION

As part of the remedial design for the Industrial Excess Landfill (IEL) in Uniontown, Ohio, design studies are being conducted to supplement the data collected during the remedial investigation (U.S.EPA, 1988). As part of these design studies, in response to public concern that low-level radioactive waste was potentially disposed of at IEL, the U.S. Environmental Protection Agency (EPA) has included sampling for radioactive compounds in the ground-water monitoring program for the site. These samples will be analyzed for alpha, beta, and gamma emitting radioactive isotopes, tritium, and carbon-14.

During the IEL Radiation Conference call on November 28, 1990, Bob Alvarez of U.S. Senator John Glenn's staff questioned the rationale for not testing for radioactivity while drilling exploratory boreholes into the landfill. EPA responded that the likelihood of detecting radioactive compounds, if present, was much greater through analysis of ground water, where these compounds would have dispersed. The probability of detecting a radioactive source in the landfill via boreholes was previously determined and presented in an EPA memorandum to the Technical Information Committee on December 27, 1990 (U.S. EPA, 1990). That study showed that the installation of 50,000 boreholes would result in a detection probability of only 0.22. This report presents the findings of EPA's study to determine the probability of detecting a radioactive source, if present, using the monitoring well network that will be expanded during the design studies.

Section 2.0 describes how the target radioactive compounds for this study were selected, and how their location within the landfill was selected. Section 3.0 describes the model (PLUME) and input assumptions used to estimate downgradient radioactive compound activities. Section 4.0 discusses the model limitations. Section 5.0 discusses the probability computations. Section 6.0 presents the results of the modeling and subsequent probability determinations. Finally, Section 7.0 provides a summary of the study and conclusions. A glossary is also provided in Appendix C to define technical terms not defined in the text. These terms have been underlined.

2.0 SOURCE TERM DEVELOPMENT

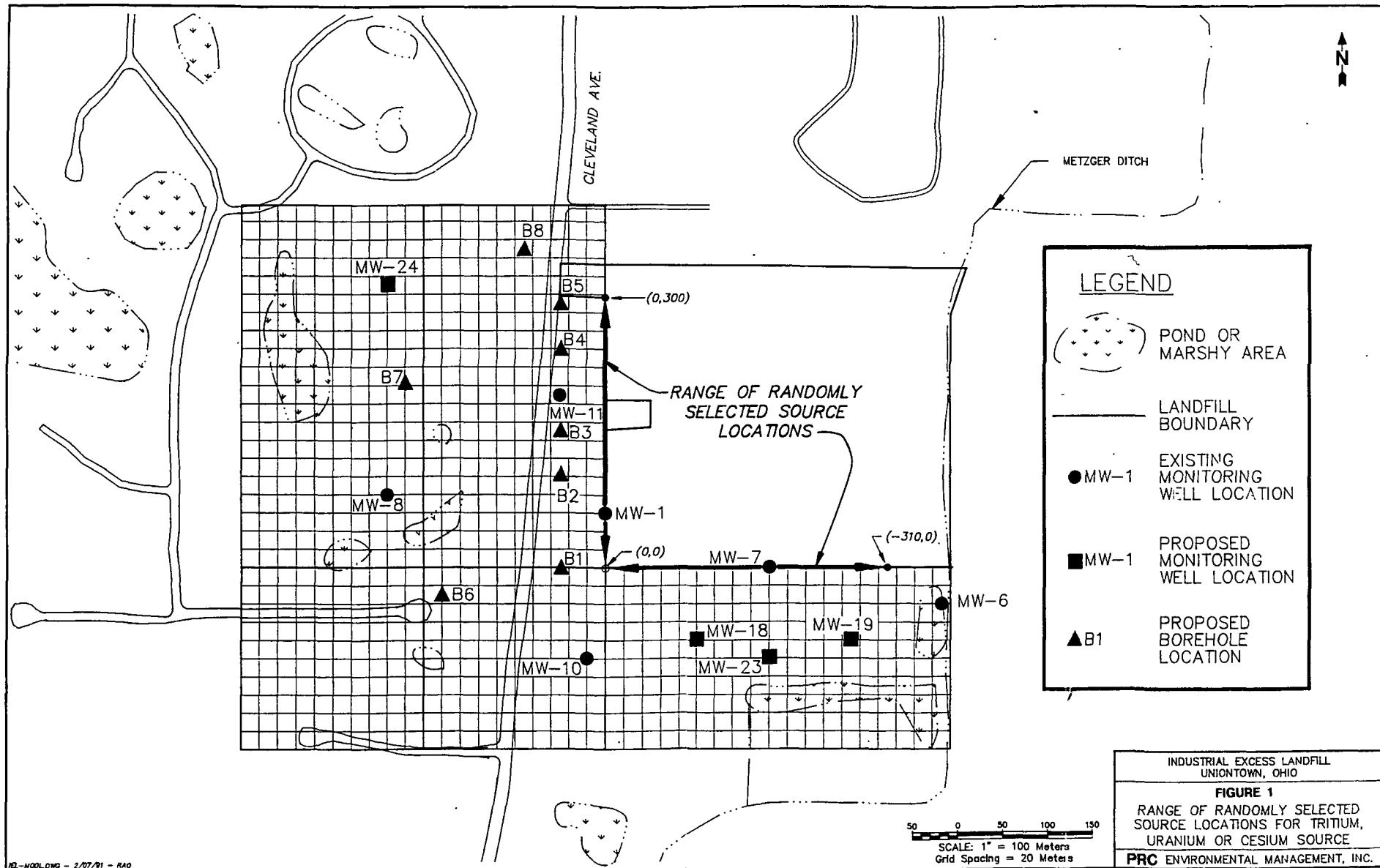
The potential radioactive sources and their estimated volumes from the state and federal licensed sources are described in the EPA memorandum of December 27, 1990 (U.S. EPA, 1990). The solid and liquid radioactive sources of potential concern and their respective activities are listed in the table below. Those compounds with short half-lives (less than one year) were not included since they would have decayed to nondetectable activities shortly after the closing of the landfill, and do not have radioactive daughter products.

<u>Radioactive Source Isotope</u>	<u>Activity in curies (Ci)</u>	<u>Mobility Class</u>
Cesium-137	1.0	1
Americium-241	0.5	1
Cobalt-60	0.1	1
Strontium-90	0.05	1
Iron-55	0.02	1
Nickel-63	0.015	1
Radium-226	0.5	1
Carbon-14	0.005	2
Hydrogen-3 (tritium)	0.3	2

These hypothetical sources can be placed into two general classes: 1) immobile compounds that, when dissolved in ground water, are strongly bound by the sediment particles in the aquifer and therefore migrate downgradient very slowly; and 2) mobile compounds that tend to move downgradient at a rate similar to that of ground water. The radioactive isotopes listed in the table above are categorized in one of these two classes based on their reported behavior in the environment. One target compound was selected from each class to compare the effects of mobility on the downgradient distribution of the target compound and the resultant probability of detection. Cesium-137 was selected as the immobile compound, because it has the greatest activity. Tritium was selected as the mobile compound. The half-lives of cesium-137 and tritium, respectively, are 30.1 years and 12.26 years.

In addition to the state and federal licensed hypothetical sources listed above, a "midnight dumper" scenario in which wastes from a reactor or fuel-processing plant were illegally disposed of at IEL was addressed. This scenario was formulated based on the allegation that a truck bearing a radioactivity placard was seen at IEL. In this scenario, 100 drums of uranium- and thorium-bearing wastes are assumed to be the hypothetical source. Based on analysis of this type of waste at the Feed Materials Production Center, a U.S. Department of Energy facility in Fernald, Ohio, estimated activities for uranium and thorium are 0.2 Ci and 0.1 Ci, respectively. Since uranium-234/238 has the higher activity, it was chosen as the third target compound for the modeling study.

The location and areal extent of the landfill with respect to the monitoring well network and proposed boreholes are shown in Figure 1. In order to model the transport and distribution of these radioactive compounds (cesium-137, tritium, and uranium-234/238) in the shallow sand



and gravel aquifer beneath the landfill, some assumptions are required regarding their location within the landfill. The location of the hypothetical radioactive source was selected to occur somewhere along the western or southern boundary of the landfill and at the bottom of the landfill, which approximately corresponds to the water table elevation. Constraining the source location to the landfill boundary results in the lowest probability of detection by the monitoring well network. Moving the hypothetical source location toward the center of the landfill increases the probability of detection because those wells located within or at the site boundaries could potentially detect the plume, and because the size of the plume increases due to downgradient dispersion. Moving the hypothetical source location upwards within the landfill increases the probability of detection because the source would become dispersed as it migrates downward towards the water table, thus creating a larger plume. The same effects that disperse the plume will also dilute the activity of the plume and may make it harder to detect. However, if the activities are diluted to below detection limits in the wells, the plume will not pose any health risk. In addition, it is assumed that the target compounds are released from a line source 1 meter in length, which corresponds to a 1 cubic yard source.

It is also assumed that the source is soluble and is instantaneously released into the aquifer. This assumption is reasonable for tritium but is less likely for cesium-137 and uranium-234/238. However, releasing these compounds as a slug (instantaneously) results in a smaller plume and therefore a lower probability of detection, thus this assumption is conservative.

In summary, the assumptions made concerning the hypothetical source location and method of introduction into the aquifer result in minimal plume dispersion. Therefore, the probabilities of detection determined in this study represent minimums.

3.0 PLUME MODEL

A three-dimensional, unidirectional analytical transport model, PLUME, was used to estimate the concentration, in curies per liter (Ci/L), of cesium-137, tritium, and uranium-234/238 downgradient from the landfill at selected time periods.

PLUME (Analytic Solution for Transport of Radioactive and Non-Radioactive Tracers in Ground Water) is a public domain computer model. It is used to calculate the concentration distribution of a contaminant in a homogeneous aquifer with solute injection in a one-dimensional flow field with three-dimensional dispersion (Van der Heijde, 1983). PLUME is distributed and supported by the International Ground Water Modeling Center, Holcomb Research Institute, Butler University. The model is based on an equation that describes the time-dependent dispersion of a solute in one direction of groundwater flow in an aquifer that is

homogeneous, isotropic, and infinite in extent. The model is supplied with constant values for porosity, hydraulic conductivity, hydraulic gradient, and dispersion coefficients. The governing equation and assumed boundary conditions, described in detail by Codell (1982), are not elaborated here.

The following simplifying assumptions are incorporated in the application of the PLUME model to the IEL site:

- A hypothetical radioactive source is located at the water table surface.
- The saturated thickness of the unconfined aquifer is uniform, and equal to 30.5 meters (U.S.EPA, 1988).
- The aquifer is homogenous and isotropic. The mean hydraulic conductivity (K) is estimated at 33.8 meters/day (U.S.EPA, 1988).
- The hydraulic gradient (I_w) for the western boundary is 0.018 feet/foot. The hydraulic gradient (I_s) for the southern boundary is 0.006 feet/foot (U.S.EPA, 1988). Due to differences between I_w and I_s and observed radial flow at the landfill, for each source scenario the model was run twice, to independently model migration to the west and to the south.
- The effective porosity (n) of the aquifer is 0.30 (U.S.EPA, 1988).
- The average interstitial velocity (v) is estimated at 2.02 meters/day at the western boundary of the IEL facility, and 0.676 meters/day at the southern boundary, where $v = KI/n$.
- The screened interval for the existing and proposed monitoring wells is from the water table to 3.1 meters below the water table.
- Retardation is defined as the ratio of the velocity of ground water to the velocity of the contaminant. Estimates of retardation are based on the following equation:

$$R = 1 + Kd(BD/n)$$

where

R	=	retardation coefficient.
n	=	porosity, assumed to be 0.3, assumed to equal the effective porosity.
Kd	=	adsorption coefficient.
BD	=	bulk density, assumed to be 1.5.

The adsorption coefficient (Kd) is defined as the ratio of the concentration of the compound adsorbed on soil surfaces to the concentration of that compound in water. The greater the extent of adsorption, the greater the value of Kd. The Kd values for the two cations (cesium-137 and uranium-234/238) in question can vary greatly depending on the cation

exchange capacity of the sediments and the ground-water chemistry. Dragun (1988) presents observed ranges for cesium of 10 to 52,000 and for uranium of 11 to 4,400. Based on values presented for comparable lithologies (U.S.EPA, 1978), Kd values for cesium and uranium were estimated at 200 and 30, respectively. Site-specific geochemical data that would have allowed a more rigorous determination of Kd values for these compounds is not available. Tritium is expected to move at the same rate as ground water (U.S.EPA, 1978), therefore its Kd value is zero.

The retardation coefficients for the three radiochemical compounds of interest based on the equation above are:

	<u>R</u>
Cesium-137	1001
Uranium	151
Tritium	1

Retardation coefficients greater than 10 indicate that a compound is generally immobile.

The assumed longitudinal (Dx) dispersivity for each of the compounds is equal to one-tenth of the mean travel distance (Gelhar and Axness, 1981). For example, the mean travel distance for tritium toward the west 100 days after release is 200 meters. Therefore, Dx = 20 meters. The transverse (Dy) dispersivity was set to equal one-third of the longitudinal dispersivity (Whitaker, 1967; U.S.EPA, 1985; Gelhar and others, 1985). To determine the effect on the shape of the plume and resultant probability of detection, Dy = 0.1(Dx) was also modeled (Mackay and others, 1985). Finally, based on vertical distribution of contaminants as deep as the intermediate wells at IEL (U.S.EPA, 1988), the vertical (Dz) dispersivity was set equal to the transverse dispersivity.

The model output tables provides activities for the radioactive compounds of concern at the nodes of a 10 x 10-meter or 20 x 20-meter grid, to a distance of 190 or 380 meters, respectively. Appendix A presents the modeling output. The source is located at the origin of the grid (0,0). The activity at the source (0,0) is assumed to equal the activity at grid node (10,0). Activities are also provided for only one-half of the plumes. To obtain activities for the other half, the output can simply be reflected across the line y = 0.

The output provides activities that are many orders of magnitude below the analytical detection limits for the source compounds. These detection limits are presented below:

<u>Compound</u>	<u>Analytical Detection Limit (Ci)</u>
Cesium-137	0.2 E - 10
Tritium	0.1 E - 08
Uranium-234/238	0.1 E - 10

The analytical detection limits for cesium-137 and tritium were set in accordance with the monitoring requirements for drinking water in 40 CFR 141, Subpart C. The analytical detection limit for uranium-234/238 was set at one-half the uranium activity being considered as a proposed maximum contaminant level.

4.0 MODEL LIMITATIONS

The estimates for the occurrence, activity, distribution, and migration of cesium-137, tritium, and uranium-234/238 at the IEL site are hypothetical. Therefore, many of the assumptions and model input parameters are hypothetical or based on scientific references that present data for similar geologic conditions. In addition, the ground-water flow regime is simplified. Most importantly, the model could not be calibrated because of a lack of site-specific downgradient monitoring well data. Therefore, this initial modeling effort provides only an estimate of the expected distribution and activity of the radioactive compounds chosen. If future investigations indicate that modifications of the modeling assumptions are necessary, the model should be updated with new data as appropriate.

5.0 PROBABILITY COMPUTATION

The probabilities of detection of the radioactive compounds of interest via the boreholes and monitoring wells west and south of the landfill are determined by the method described below:

1. Use a bivariate interpolation method on the contaminant activities at the grid nodes as determined by the model. The contaminant activities are determined for all locations within the plume by linearly interpolating in both the x and y directions.
2. Generate a hypothetical source point location on the western or southern boundary with equal probability, using a uniform random number generator.

3. Shift the model output in conjunction with the shift of the hypothetical source location from the origin to the new, randomly generated hypothetical source location on either the western or southern boundary.
4. Determine which of the boreholes and monitoring wells detect the contamination by comparing the activity at that monitoring location to the analytical detection limit for the compound modeled.

For each scenario considered, steps 1 - 4 were repeated 10,000 times in the computer program, and the number of times the boreholes and monitoring wells detected the contamination were counted. The detection probability for a borehole or monitoring well is estimated by:

$$P(\text{detection by a borehole or monitoring well}) = \frac{\text{Number of times the borehole or well detected contamination}}{10,000}$$

Assuming that the boreholes and monitoring wells act independently of one another, the following was also computed, for boreholes/monitoring wells

$$P(\text{at least one detection}) = 1 - \prod (1-p(\text{detection by i-th unit})).$$

During the advancement of the exploratory boreholes, the ground water will be screened in an on-site laboratory for target metal and organic contaminants. Based on the results of this screening, a minimum of four of the eight boreholes will be converted to monitoring wells. Therefore, the minimum probability of detection for the future monitoring well network should approximately equal the probability of detection in the fixed monitoring wells plus one-half the probability of detection in the boreholes. The actual number of boreholes to be converted to monitoring wells may be greater.

The detection probabilities for each compound and the various scenarios modeled are presented in Appendix B.

6.0 RESULTS

Although data for many different scenarios were generated, only the most instructive data are provided in the appendices and discussed in detail below. Tritium, cesium-137, and uranium-234/238 are presented in Sections 6.1, 6.2, and 6.3, respectively.

6.1

TRITIUM

PLUME was run to model the activity of tritium downgradient from the hypothetical source 100 days after release into the aquifer. The model output is presented in Appendix A-1. The maximum activity to the west of the landfill is 0.45×10^{-9} Ci/L at a location 200 meters downgradient from the source. This concentration is below the detection limit of 0.10×10^{-8} Ci/L for tritium. To the south, the detectable downgradient region of tritium is about 100×60 meters in extent. This region (plume) is depicted graphically in Figure 2. The probability of detection for this plume is presented in Table B-1. The probability of detection in at least one of the fixed monitoring wells is 0.266. However, this determination includes those random hypothetical source locations on the western boundary, where the downgradient activity of tritium is below detection limits at all locations after 100 days.

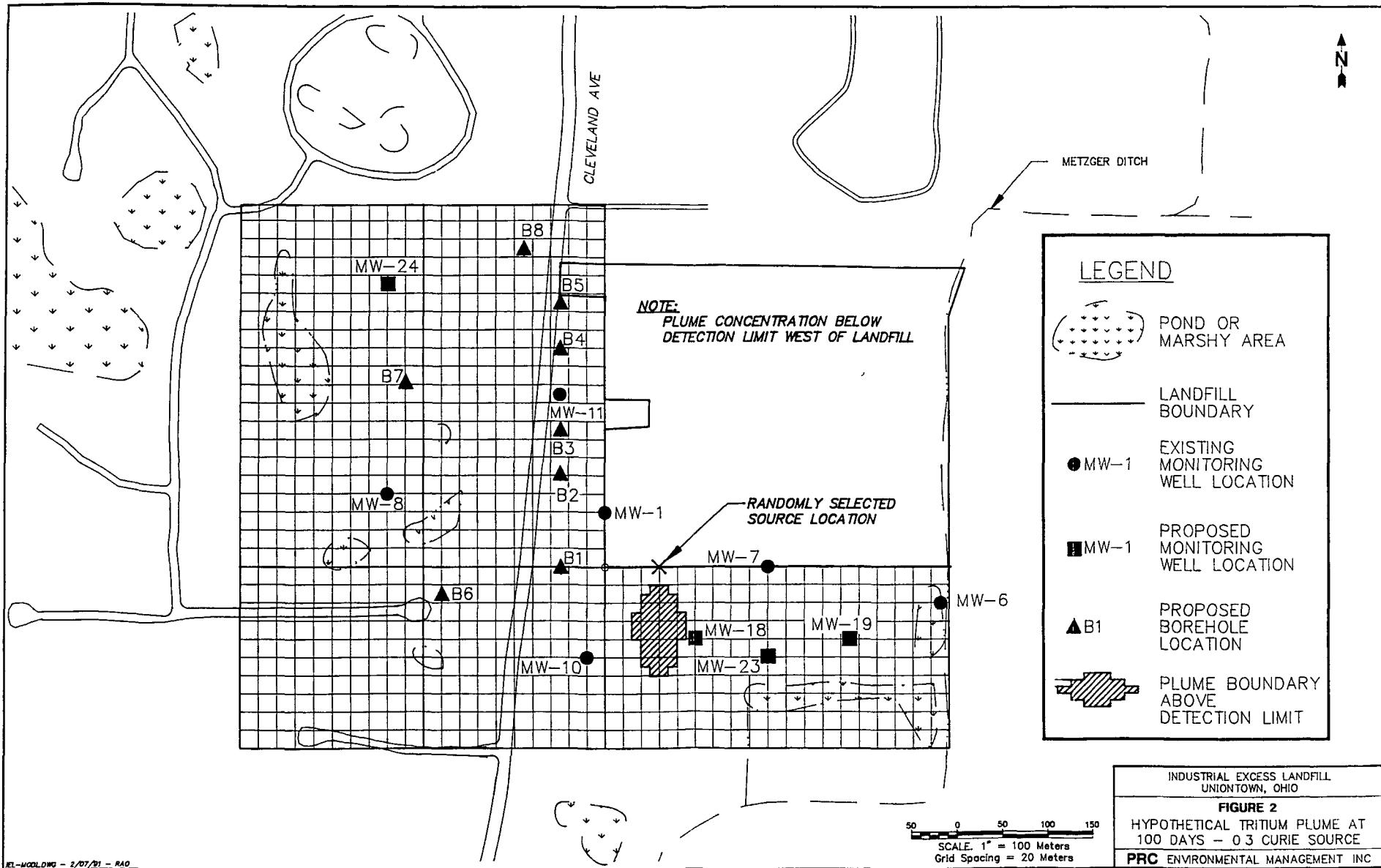
If a shorter timeframe is considered, for example, 30 days, the plume would be detectable to the west rather than the south. The detectable extent of the tritium plume to the south would extend only about 40 meters from the southern boundary, therefore, all of the wells to the south are located beyond the detectable boundaries of the plume. However, the plume is readily detected by the north/south line of boreholes and wells located about 50 meters west of the western boundary of the landfill, since the maximum tritium activity occurs at about 65 meters west of the hypothetical source.

If a longer timeframe is considered, for example one year, the tritium activity is dispersed and diluted to levels below the analytical detection limit to both the south and the west.

6.2

CESIUM-137

Cesium is an immobile compound. Therefore, the timeframe of interest is measured in tens of years, rather than days. For the hypothetical source activity of interest (1 Ci), PLUME was run for 25-year and 100-year timeframes. Twenty-five years approximately coincides with the opening of the landfill. Twenty-five years after release into the aquifer, detectable activities of cesium-137 extend only 40 meters toward the west and about 15 meters to the south. The model output is presented in Appendix A-2. Therefore, all the wells and boreholes are located beyond the detectable downgradient extent of the plume. After 100 years, the maximum cesium-137 activity to the west is 0.35×10^{-11} Ci/L, 70 meters downgradient of the hypothetical source. However, this activity is below the analytical detection limit of 0.2×10^{-10} Ci/L. The extent of the detectable downgradient plume toward the south is 40 meters. Once again, the wells are located beyond the detectable limits of the plume. If timeframes longer than 100 years are considered, the activity of cesium-137 decreases to below detectable activities beyond 50 meters



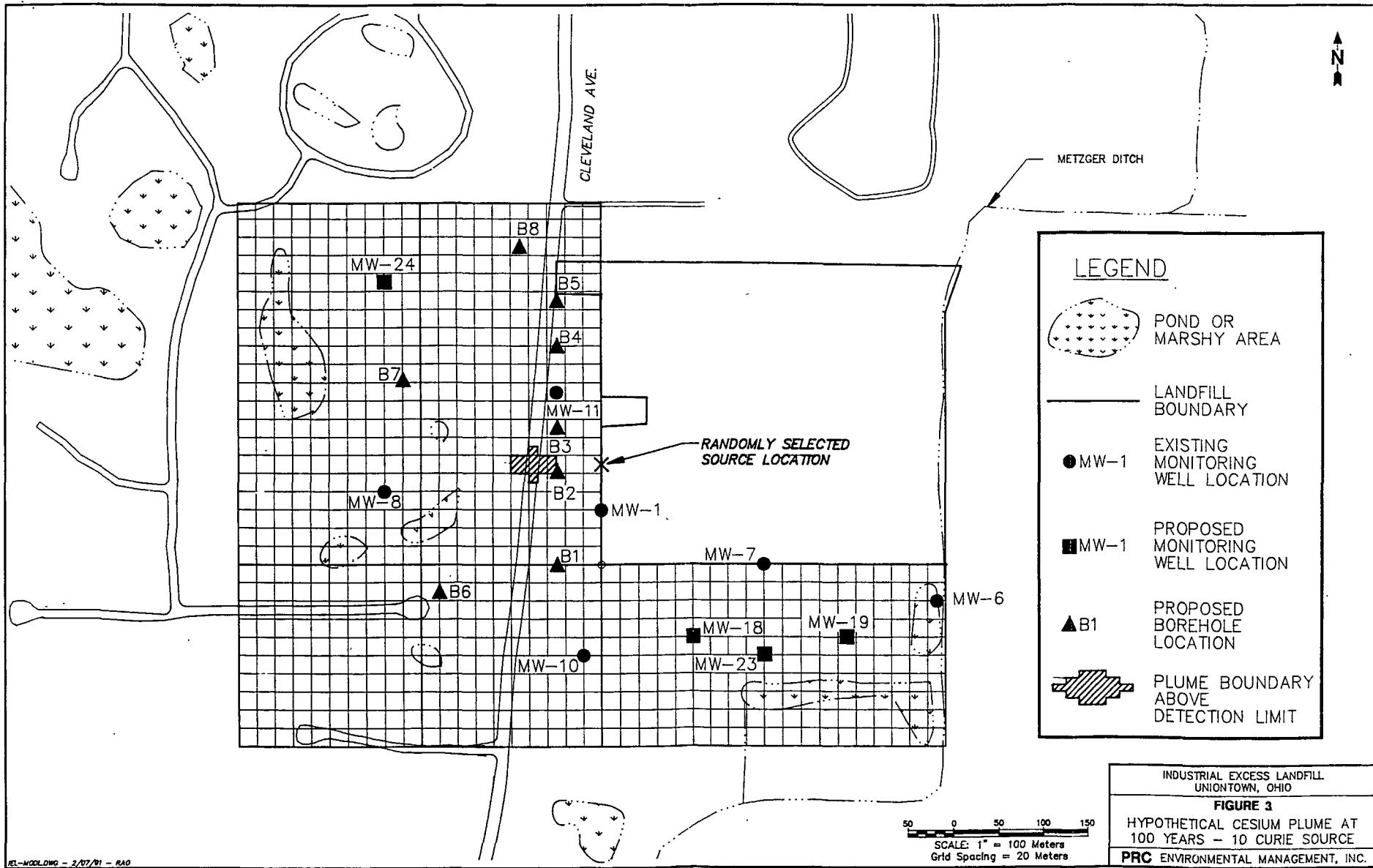
downgradient to the south. Based on the migration rate and half-life of cesium-137, cesium-137 activities are below analytical detection limits at all wells or boreholes to the west and south of the landfill.

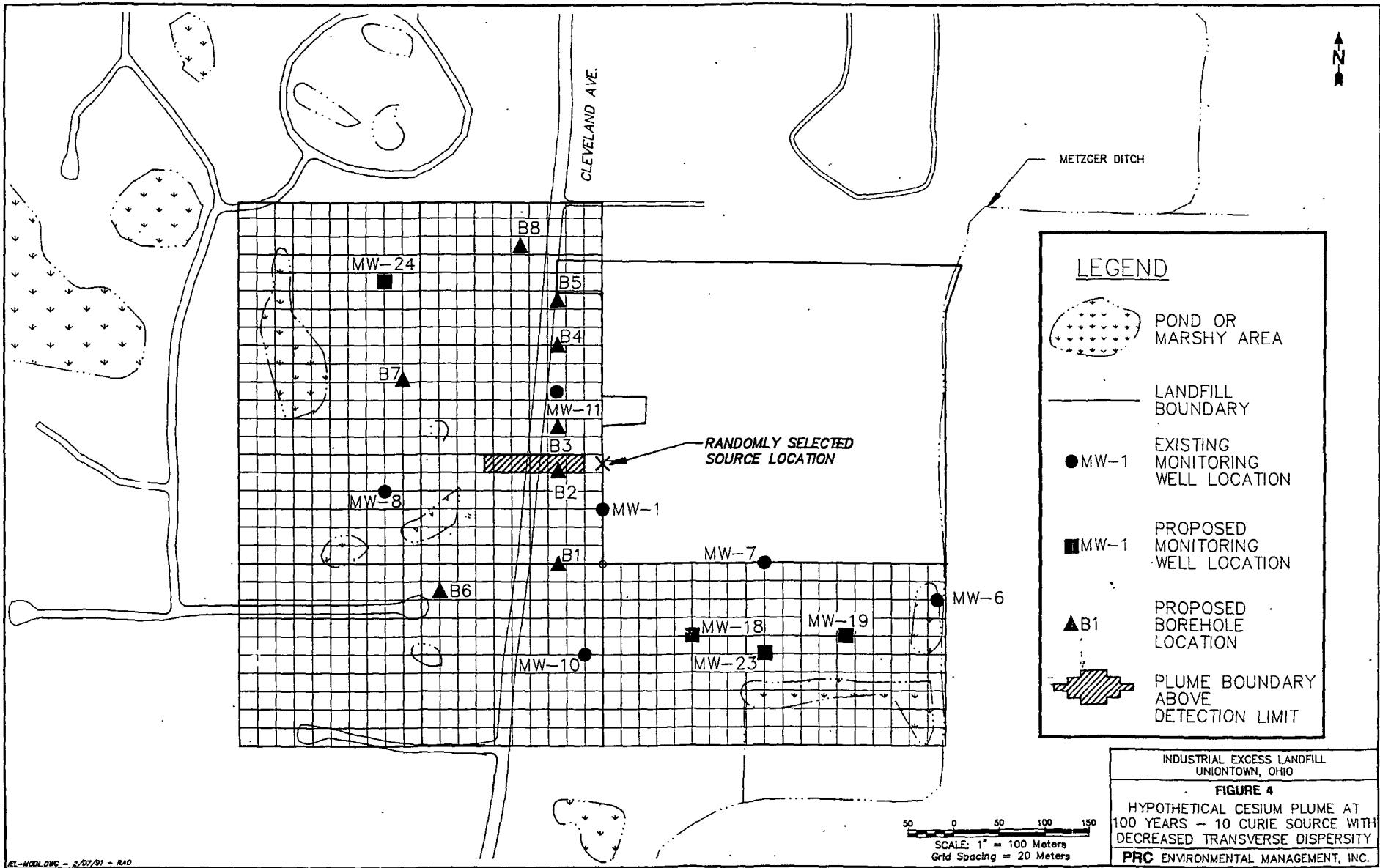
Because a hypothetical source concentration of 1 Ci resulted in cesium-137 activities below analytical detection limits beyond 50 meters downgradient from that source, the hypothetical source strength was arbitrarily increased to 10 Ci to determine the effectiveness of the well network in identifying an immobile source plume just above analytical detection limits. The 100-year timeframe was modeled. The model output presented in Appendix A-2 should be multiplied by 10 to obtain the correct activities for the 10 Ci source strength. The detectable downgradient region of cesium-137 to the west is shown as an example plume in Figure 3. Similar to the previous example, the plume activities are below analytical detection limits beyond 50 meters downgradient of the hypothetical source to the south. The probabilities of detection are shown in Table B-2. The probabilities are low (0.096 for detection by at least one fixed monitoring well and 0.191 for detection by the future monitoring well network) because despite the arbitrary increase in the hypothetical source strength, the plume does not extend beyond 50 meters to the south or 100 meters to the west.

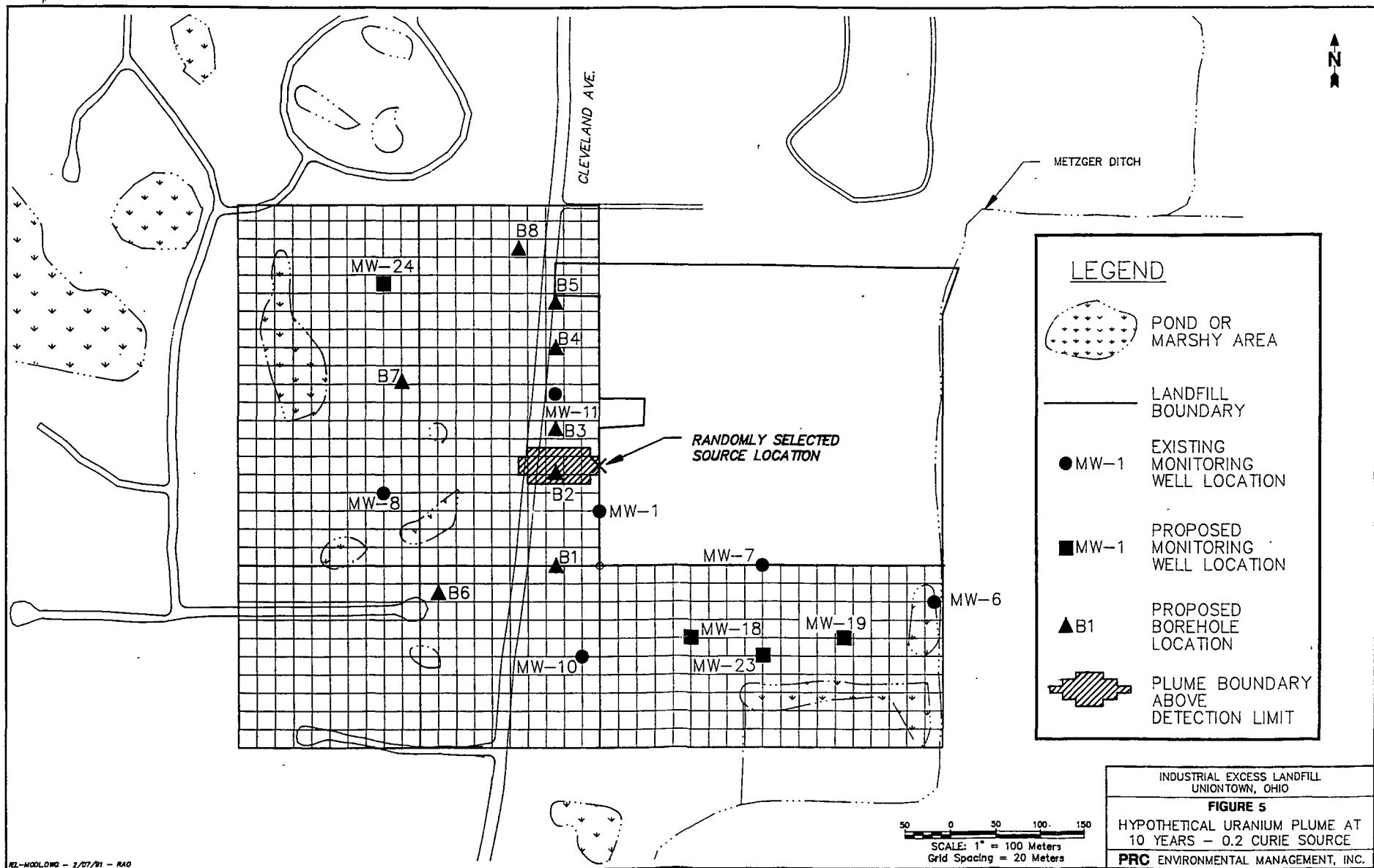
Since real time field data were not available to calibrate the model, the assumption that the transverse dispersivity is equal to one-third of the longitudinal dispersivity $D_y = (1/3)D_x$ could not be tested. Therefore, a sensitivity analysis was conducted by decreasing transverse dispersivity, setting $D_y = (1/10)D_x$, and comparing the shapes of the plumes. The model output is presented in Appendix A-3 and the resultant example plume can be seen in Figure 4. As indicated in the figures, the plume generated from the decreased D_y value is somewhat narrowed and elongated. Therefore, it might be inferred that the probability of detection would decrease. However, the probability of detection in this example (see Table B-2) is approximately the same as that in the previous example where $D_y = (1/3)D_x$, indicating that the effects are minor.

6.3 URANIUM 234/238

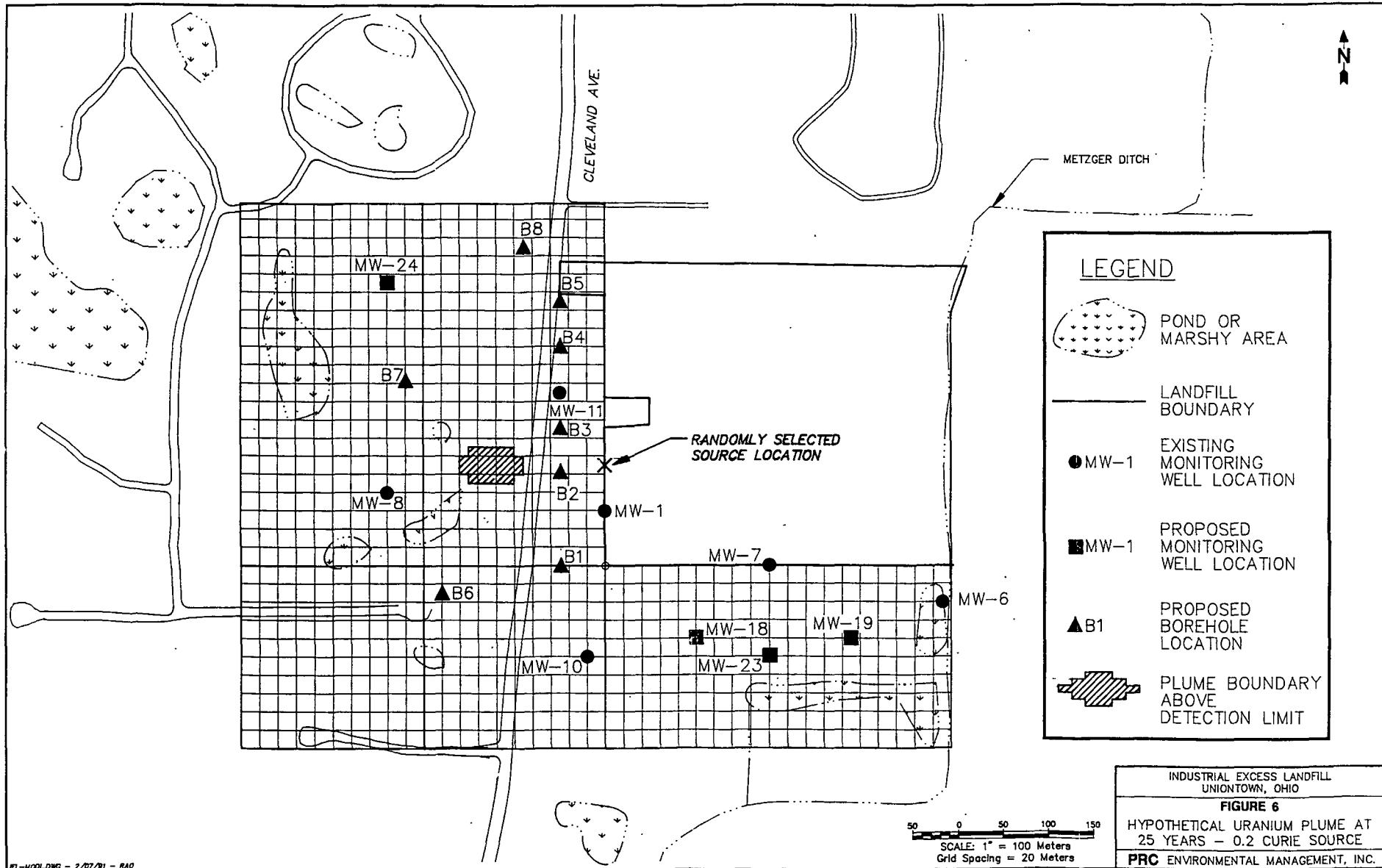
Uranium, although more mobile than cesium, is still an immobile compound. Therefore, pertinent timeframes of 10 and 25 years were selected for modeling this compound. Ten years approximates the closure of the landfill. Ten years after release into the aquifer, activities greater than the analytical detection limit extend 100 meters to the west and 40 meters to the south (see Appendix A-4). An example plume is shown in Figure 5. The probability of detection is 0.171 for at least one fixed monitoring well and 0.349 for the future monitoring well network (see Table B-3). Twenty-five years after release, the extent of the plume is 160 meters west and 80 meters south (see Appendix A-5). An example plume is shown in Figure 6. The







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FIGURE 5
HYPOTHETICAL URANIUM PLUME AT 10 YEARS - 0.2 CURIE SOURCE
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probability of detection is 0.105 for either the fixed monitoring wells or for the future monitoring well network. The decreased probability is due to the location of the plume between the wells along the western boundary (see Figure 6). The detectable extent of the plume to the south just reaches those wells to the south. After 50 years, the plume would be dispersed to the extent that it could no longer be detected.

7.0 SUMMARY AND CONCLUSIONS

Cesium-137 and tritium were selected as two of the target compounds for this study. These compounds were chosen from a compilation of potential radiological contaminants presented in the EPA memorandum of December 27, 1990 (U.S. EPA, 1990). ~~Cesium-137 was selected because it is the immobile compound with the greatest activity. Tritium was selected because it is the mobile compound with the greatest activity. Uranium-234/238 was also modeled to address a hypothetical scenario in which a truck illegally disposed of a larger quantity of radioactive waste.~~ However, no evidence exists suggesting that any of these potential radiochemical contaminants are present.

~~The location of the potential radiochemical sources along either the western or southern boundary at the water table is extremely conservative in that these locations result in a minimum probability of detection of a downgradient plume by the monitoring well network. The input parameters chosen for the PLUME mode are based on available site data and accepted modeling practices. However, no activity data for downgradient radiochemical compounds exist to calibrate the model. Therefore, the distribution and activity of the compounds modeled are theoretical and estimated.~~

The probabilities of detection via either monitoring wells or boreholes were determined by randomly locating the hypothetical source along the western or southern landfill boundary and determining whether a monitoring well or borehole is within the boundaries of detectable plume activities modeled from that source. ~~Assuming that the minimum of four of the eight boreholes will be converted to monitoring wells, the probability of detection by the future monitoring well network ranges from 0.105 to 0.349 for uranium-234/238 and tritium. Cesium-137 is not present above detection limits at any of the monitoring points. After arbitrarily increasing the hypothetical source strength 10 times, the probability of detection for cesium-137 approximately 0.91. If the hypothetical source activities were significantly higher than those modeled, although the use of higher source activities cannot be supported, the probability of detection would be significantly greater.~~

More important than the probability of detection is the model results, indicating that the radioactive compound activity is reduced significantly and more rapidly than predicted by hypothesis sources, are used above the ground surface and beyond monitoring wells. Geiumium-238 is now detectable beyond 50 meters away from the source, stronger by 10 times, than cesium-137 which is detectable beyond 100 meters away. Tritium activities are below detection limits between 200 and 300 meters. Since the standard deviation limit is at least 3 times below the mean, the plume reaches 200 meters. Since the standard deviation limit is at least 3 times below the mean, the plume reaches 200 meters. Compounds in the plume are detected at a distance of 200 meters. These compounds are probably due to the detection of cesium-137 which has a half-life of 30 years.

8.0 REFERENCES

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APPENDIX A

PLUME MODELING OUTPUT

APPENDIX A-1
TRITIUM

CALCULATION OF CONCENTRATION VALUES FOR A SINGLE RADIOACTIVE
OR NON-RADIOACTIVE TRACER IN A HOMOGENEOUS TWO- OR THREE-
DIMENSIONAL GROUND WATER SYSTEM WITH UNI-LATERAL REGIONAL FLOW

3H .3CI south

***** INPUT DATA *****

AVERAGE INTERSTITIAL VELOCITY: .676 [M/DAY]

HALF LIFE TIME: 12.26 YRS

RETARDATION FACTOR: 1

AQUIFER THICKNESS: 30.5 [M]

EFFECTIVE POROSITY: .3

LENGTH OF LINE SOURCE: 1 [M]

DISPERSIVITY IN X-DIRECTION: 7 [M]

DISPERSIVITY IN Y-DIRECTION: 2.3 [M]

DISPERSIVITY IN Z-DIRECTION: 2.3 [M]

VERTICAL POSITION OF SOURCE BENEATH SURFACE: 0 [M]

----- SOURCE STRENGTH TABLE -----

NUMBER OF DATA PAIRS IN TABLE: 3

T(1)= 0	SEC	W(1)= .1285	CI/SEC
T(2)= 1	SEC	W(2)= .1285	CI/SEC
T(3)= 1.0001	SEC	W(3)= 0	CI/SEC

AREA UNDER PULSE IN GRAPH (= TOTAL MASS RELEASE): .1285064 CURIES
TIME CENTROID: 5.787327E-06 DAYS (= .500025 SEC)

NUMBER OF DIVISIONS IN SOURCE PULSE: 10

CALCULATION TIME: 100 DAY

----- GRID DATA -----

DEPTH OF (HORIZONTAL) GRID BENEATH SURFACE (= Z-POSITION): 3 [M]

X-COORDINATE OF ORIGIN OF GRID: 0 [M]
GRID SPACING IN X-DIRECTION: 10 [M]
NUMBER OF NODES IN X-DIRECTION: 20

Y-COORDINATE OF ORIGIN OF GRID: 0 [M]
GRID SPACING IN Y-DIRECTION: 10 [M]
NUMBER OF NODES IN Y-DIRECTION: 10

***** RESULTS *****

----- CONCENTRATION IN [CI/L] -----

X-> 0 10 20 30 40 50

Y

0	-.1000E+01	0.9302E-09	0.1622E-08	0.2544E-08	0.3590E-08	0.4558E-08
10	0.4086E-09	0.7917E-09	0.1380E-08	0.2165E-08	0.3055E-08	0.3879E-08
20	0.2523E-09	0.4888E-09	0.8522E-09	0.1337E-08	0.1886E-08	0.2395E-08
30	0.1129E-09	0.2187E-09	0.3813E-09	0.5981E-09	0.8441E-09	0.1072E-08
40	0.3665E-10	0.7102E-10	0.1238E-09	0.1942E-09	0.2740E-09	0.3480E-09
50	0.8639E-11	0.1674E-10	0.2918E-10	0.4577E-10	0.6459E-10	0.8201E-10
60	0.1478E-11	0.2864E-11	0.4993E-11	0.7831E-11	0.1105E-10	0.1403E-10
70	0.1833E-12	0.3552E-12	0.6193E-12	0.9714E-12	0.1371E-11	0.1741E-11
80	0.1644E-13	0.3185E-13	0.5552E-13	0.8709E-13	0.1229E-12	0.1561E-12
90	0.1264E-14	0.2450E-14	0.4271E-14	0.6699E-14	0.9454E-14	0.1200E-13

X->	60	70	80	90	100	110
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Y

0	0.5207E-08	0.5352E-08	0.4949E-08	0.4118E-08	0.3083E-08	0.2077E-08
10	0.4432E-08	0.4555E-08	0.4213E-08	0.3505E-08	0.2624E-08	0.1767E-08
20	0.2736E-08	0.2812E-08	0.2601E-08	0.2164E-08	0.1620E-08	0.1091E-08
30	0.1224E-08	0.1258E-08	0.1164E-08	0.9684E-09	0.7249E-09	0.4883E-09
40	0.3975E-09	0.4086E-09	0.3779E-09	0.3144E-09	0.2354E-09	0.1585E-09
50	0.9369E-10	0.9630E-10	0.8906E-10	0.7410E-10	0.5547E-10	0.3736E-10
60	0.1603E-10	0.1648E-10	0.1524E-10	0.1268E-10	0.9492E-11	0.6393E-11
70	0.1988E-11	0.2044E-11	0.1890E-11	0.1573E-11	0.1177E-11	0.7930E-12
80	0.1783E-12	0.1832E-12	0.1695E-12	0.1410E-12	0.1056E-12	0.7110E-13
90	0.1371E-13	0.1410E-13	0.1304E-13	0.1085E-13	0.8120E-14	0.5469E-14

X->	120	130	140	150	160	170
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Y

0	0.1258E-08	0.6862E-09	0.3366E-09	0.1486E-09	0.5900E-10	0.2108E-10
10	0.1071E-08	0.5840E-09	0.2865E-09	0.1265E-09	0.5022E-10	0.1794E-10
20	0.6613E-09	0.3606E-09	0.1769E-09	0.7808E-10	0.3101E-10	0.1108E-10
30	0.2959E-09	0.1613E-09	0.7915E-10	0.3494E-10	0.1387E-10	0.4957E-11
40	0.9607E-10	0.5238E-10	0.2570E-10	0.1134E-10	0.4505E-11	0.1610E-11
50	0.2264E-10	0.1235E-10	0.6057E-11	0.2673E-11	0.1062E-11	0.3793E-12
60	0.3874E-11	0.2113E-11	0.1036E-11	0.4574E-12	0.1817E-12	0.6491E-13
70	0.4806E-12	0.2620E-12	0.1286E-12	0.5674E-13	0.2253E-13	0.8051E-14
80	0.4309E-13	0.2349E-13	0.1153E-13	0.5087E-14	0.2020E-14	0.7218E-15
90	0.3314E-14	0.1807E-14	0.8866E-15	0.3913E-15	0.1554E-15	0.5553E-16

X->	180	190
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Y

0	0.6777E-11	0.1960E-11
10	0.5769E-11	0.1669E-11
20	0.3562E-11	0.1030E-11
30	0.1594E-11	0.4610E-12
40	0.5174E-12	0.1497E-12
50	0.1220E-12	0.3527E-13
60	0.2087E-13	0.6036E-14
70	0.2588E-14	0.7486E-15
80	0.2321E-15	0.6712E-16
90	0.1785E-16	0.5163E-17

CALCULATION OF CONCENTRATION VALUES FOR A SINGLE RADIOACTIVE
OR NON-RADIOACTIVE TRACER IN A HOMOGENEOUS TWO- OR THREE-
DIMENSIONAL GROUND WATER SYSTEM WITH UNI-LATERAL REGIONAL FLOW

3H .3CI west

***** INPUT DATA *****

AVERAGE INTERSTITIAL VELOCITY: 2.02 [M/DAY]

HALF LIFE TIME: 12.26 YRS

RETARDATION FACTOR: 1

AQUIFER THICKNESS: 30.5 [M]

EFFECTIVE POROSITY: .3

LENGTH OF LINE SOURCE: 1 [M]

DISPERSIVITY IN X-DIRECTION: 20 [M]

DISPERSIVITY IN Y-DIRECTION: 6.7 [M]

DISPERSIVITY IN Z-DIRECTION: 6.7 [M]

VERTICAL POSITION OF SOURCE BENEATH SURFACE: 0 [M]

----- SOURCE STRENGTH TABLE -----

NUMBER OF DATA PAIRS IN TABLE: 3

T(1)= 0	SEC	W(1)= .1285	CI/SEC
T(2)= 1	SEC	W(2)= .1285	CI/SEC
T(3)= 1.0001	SEC	W(3)= 0	CI/SEC

AREA UNDER PULSE IN GRAPH (= TOTAL MASS RELEASE): .1285064 CURIES
TIME CENTROID: 5.787327E-06 DAYS (= .500025 SEC)

NUMBER OF DIVISIONS IN SOURCE PULSE: 10

CALCULATION TIME: 100 DAY

----- GRID DATA -----

DEPTH OF (HORIZONTAL) GRID BENEATH SURFACE (= Z-POSITION): 3 [M]

X-COORDINATE OF ORIGIN OF GRID: 0 [M]
GRID SPACING IN X-DIRECTION: 10 [M]
NUMBER OF NODES IN X-DIRECTION: 20

Y-COORDINATE OF ORIGIN OF GRID: 0 [M]
GRID SPACING IN Y-DIRECTION: 10 [M]
NUMBER OF NODES IN Y-DIRECTION: 10

***** RESULTS *****

----- CONCENTRATION IN [CI/L] -----

X-> 0 10 20 30 40 50

Y

0	-.1000E+01	0.4650E-10	0.5861E-10	0.7297E-10	0.8972E-10	0.1090E-09
10	0.3575E-10	0.4562E-10	0.5750E-10	0.7158E-10	0.8802E-10	0.1069E-09
20	0.3382E-10	0.4316E-10	0.5440E-10	0.6772E-10	0.8327E-10	0.1011E-09
30	0.3084E-10	0.3936E-10	0.4961E-10	0.6176E-10	0.7594E-10	0.9223E-10
40	0.2711E-10	0.3459E-10	0.4360E-10	0.5428E-10	0.6674E-10	0.8105E-10
50	0.2296E-10	0.2929E-10	0.3692E-10	0.4596E-10	0.5652E-10	0.6864E-10
60	0.1873E-10	0.2390E-10	0.3013E-10	0.3751E-10	0.4612E-10	0.5601E-10
70	0.1473E-10	0.1880E-10	0.2369E-10	0.2950E-10	0.3627E-10	0.4405E-10
80	0.1116E-10	0.1425E-10	0.1796E-10	0.2235E-10	0.2749E-10	0.3338E-10
90	0.8155E-11	0.1041E-10	0.1312E-10	0.1633E-10	0.2008E-10	0.2438E-10

X->	60	70	80	90	100	110
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Y

0	0.1307E-09	0.1549E-09	0.1812E-09	0.2094E-09	0.2391E-09	0.2696E-09
10	0.1282E-09	0.1519E-09	0.1778E-09	0.2055E-09	0.2346E-09	0.2645E-09
20	0.1213E-09	0.1437E-09	0.1682E-09	0.1944E-09	0.2219E-09	0.2502E-09
30	0.1106E-09	0.1311E-09	0.1534E-09	0.1773E-09	0.2024E-09	0.2282E-09
40	0.9722E-10	0.1152E-09	0.1348E-09	0.1558E-09	0.1779E-09	0.2005E-09
50	0.8233E-10	0.9755E-10	0.1141E-09	0.1319E-09	0.1506E-09	0.1698E-09
60	0.6719E-10	0.7960E-10	0.9315E-10	0.1077E-09	0.1229E-09	0.1386E-09
70	0.5283E-10	0.6260E-10	0.7325E-10	0.8467E-10	0.9665E-10	0.1090E-09
80	0.4004E-10	0.4744E-10	0.5552E-10	0.6417E-10	0.7325E-10	0.8260E-10
90	0.2925E-10	0.3465E-10	0.4055E-10	0.4687E-10	0.5351E-10	0.6033E-10

X->	120	130	140	150	160	170
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Y

0	0.3002E-09	0.3303E-09	0.3588E-09	0.3850E-09	0.4081E-09	0.4272E-09
10	0.2945E-09	0.3240E-09	0.3520E-09	0.3777E-09	0.4004E-09	0.4191E-09
20	0.2787E-09	0.3065E-09	0.3330E-09	0.3574E-09	0.3788E-09	0.3965E-09
30	0.2541E-09	0.2795E-09	0.3037E-09	0.3259E-09	0.3454E-09	0.3616E-09
40	0.2233E-09	0.2457E-09	0.2669E-09	0.2864E-09	0.3036E-09	0.3178E-09
50	0.1891E-09	0.2080E-09	0.2260E-09	0.2426E-09	0.2571E-09	0.2691E-09
60	0.1543E-09	0.1698E-09	0.1844E-09	0.1979E-09	0.2098E-09	0.2196E-09
70	0.1214E-09	0.1335E-09	0.1450E-09	0.1557E-09	0.1650E-09	0.1727E-09
80	0.9199E-10	0.1012E-09	0.1099E-09	0.1180E-09	0.1250E-09	0.1309E-09
90	0.6719E-10	0.7391E-10	0.8030E-10	0.8617E-10	0.9133E-10	0.9561E-10

X->	180	190
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Y

0	0.4417E-09	0.4511E-09
10	0.4334E-09	0.4426E-09
20	0.4100E-09	0.4187E-09
30	0.3739E-09	0.3819E-09
40	0.3286E-09	0.3356E-09
50	0.2783E-09	0.2842E-09
60	0.2271E-09	0.2319E-09
70	0.1786E-09	0.1824E-09
80	0.1353E-09	0.1382E-09
90	0.9886E-10	0.1010E-09

CALCULATION TIME: 100 DAY

----- GRID DATA -----

DEPTH OF (HORIZONTAL) GRID BENEATH SURFACE (= Z-POSITION): 3 [M]

X-COORDINATE OF ORIGIN OF GRID: 0 [M]
GRID SPACING IN X-DIRECTION: 20 [M]
NUMBER OF NODES IN X-DIRECTION: 20

Y-COORDINATE OF ORIGIN OF GRID: 0 [M]
GRID SPACING IN Y-DIRECTION: 20 [M]
NUMBER OF NODES IN Y-DIRECTION: 10

***** RESULTS *****

----- CONCENTRATION IN [CI/L] -----

X-> 0 20 40 60 80 100

Y

0	-.1000E+01	0.5861E-10	0.8972E-10	0.1307E-09	0.1812E-09	0.2391E-09
20	0.3382E-10	0.5440E-10	0.8327E-10	0.1213E-09	0.1682E-09	0.2219E-09
40	0.2711E-10	0.4360E-10	0.6674E-10	0.9722E-10	0.1348E-09	0.1779E-09
60	0.1873E-10	0.3013E-10	0.4612E-10	0.6719E-10	0.9315E-10	0.1229E-09
80	0.1116E-10	0.1796E-10	0.2749E-10	0.4004E-10	0.5552E-10	0.7325E-10
100	0.5741E-11	0.9234E-11	0.1414E-10	0.2059E-10	0.2855E-10	0.3767E-10
120	0.2548E-11	0.4098E-11	0.6273E-11	0.9139E-11	0.1267E-10	0.1672E-10
140	0.9760E-12	0.1570E-11	0.2403E-11	0.3501E-11	0.4854E-11	0.6404E-11
160	0.3228E-12	0.5191E-12	0.7946E-12	0.1158E-11	0.1605E-11	0.2118E-11
180	0.9201E-13	0.1480E-12	0.2265E-12	0.3300E-12	0.4576E-12	0.6037E-12

X->	120	140	160	180	200	220
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Y

0	0.3002E-09	0.3588E-09	0.4081E-09	0.4417E-09	0.4551E-09	0.4461E-09
20	0.2787E-09	0.3330E-09	0.3788E-09	0.4100E-09	0.4224E-09	0.4141E-09
40	0.2233E-09	0.2669E-09	0.3036E-09	0.3286E-09	0.3385E-09	0.3319E-09
60	0.1543E-09	0.1844E-09	0.2098E-09	0.2271E-09	0.2339E-09	0.2293E-09
80	0.9199E-10	0.1099E-09	0.1250E-09	0.1353E-09	0.1394E-09	0.1367E-09
100	0.4730E-10	0.5653E-10	0.6430E-10	0.6960E-10	0.7169E-10	0.7029E-10
120	0.2099E-10	0.2509E-10	0.2854E-10	0.3089E-10	0.3182E-10	0.3120E-10
140	0.8042E-11	0.9611E-11	0.1093E-10	0.1183E-10	0.1219E-10	0.1195E-10
160	0.2659E-11	0.3178E-11	0.3615E-11	0.3913E-11	0.4030E-11	0.3951E-11
180	0.7581E-12	0.9060E-12	0.1030E-11	0.1115E-11	0.1149E-11	0.1127E-11

X->	240	260	280	300	320	340
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Y

0	0.4163E-09	0.3696E-09	0.3124E-09	0.2512E-09	0.1923E-09	0.1401E-09
20	0.3864E-09	0.3431E-09	0.2899E-09	0.2332E-09	0.1785E-09	0.1300E-09
40	0.3096E-09	0.2750E-09	0.2324E-09	0.1869E-09	0.1430E-09	0.1042E-09
60	0.2140E-09	0.1900E-09	0.1606E-09	0.1291E-09	0.9885E-10	0.7201E-10
80	0.1275E-09	0.1132E-09	0.9570E-10	0.7697E-10	0.5892E-10	0.4292E-10
100	0.6558E-10	0.5824E-10	0.4921E-10	0.3958E-10	0.3030E-10	0.2207E-10
120	0.2911E-10	0.2585E-10	0.2184E-10	0.1757E-10	0.1345E-10	0.9795E-11
140	0.1115E-10	0.9901E-11	0.8367E-11	0.6729E-11	0.5151E-11	0.3752E-11
160	0.3687E-11	0.3274E-11	0.2767E-11	0.2225E-11	0.1703E-11	0.1241E-11
180	0.1051E-11	0.9333E-12	0.7887E-12	0.6344E-12	0.4856E-12	0.3537E-12

X->	360	380
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Y

0	0.9711E-10	0.6407E-10
20	0.9014E-10	0.5947E-10
40	0.7224E-10	0.4766E-10
60	0.4992E-10	0.3294E-10
80	0.2975E-10	0.1963E-10
100	0.1530E-10	0.1009E-10
120	0.6791E-11	0.4480E-11
140	0.2601E-11	0.1716E-11
160	0.8601E-12	0.5675E-12
180	0.2452E-12	0.1618E-12

APPENDIX A-2

CESIUM-137
Dy = 1/3(Dx)

CALCULATION OF CONCENTRATION VALUES FOR A SINGLE RADIOACTIVE OR NON-RADIOACTIVE TRACER IN A HOMOGENEOUS TWO- OR THREE-DIMENSIONAL GROUND WATER SYSTEM WITH UNI-LATERAL REGIONAL FLOW

Cs137 9125 days 1Cl west

***** INPUT DATA *****

AVERAGE INTERSTITIAL VELOCITY: 2.02 [M/DAY]

HALF LIFE TIME: 30.1 YRS

RETARDATION FACTOR: 1000

AQUIFER THICKNESS: 30.5 [M]

EFFECTIVE POROSITY: .3

LENGTH OF LINE SOURCE: 1 [M]

DISPERSIVITY IN X-DIRECTION: 1.8 [M]

DISPERSIVITY IN Y-DIRECTION: .6 [M]

DISPERSIVITY IN Z-DIRECTION: .6 [M]

VERTICAL POSITION OF SOURCE BENEATH SURFACE: 0 [M]

----- SOURCE STRENGTH TABLE -----

NUMBER OF DATA PAIRS IN TABLE: 3

T(1)= 0	SEC	W(1)= 1	CI/SEC
T(2)= 1	SEC	W(2)= 1	CI/SEC
T(3)= 1.0001	SEC	W(3)= 0	CI/SEC

AREA UNDER PULSE IN GRAPH (= TOTAL MASS RELEASE): 1.00005 CURIES
TIME CENTROID: 5.787326E-06 DAYS (= .500025 SEC)

NUMBER OF DIVISIONS IN SOURCE PULSE: 10

CALCULATION TIME: 9125 DAY

GRID DATA

DEPTH OF (HORIZONTAL) GRID BENEATH SURFACE (= Z-POSITION): 3 [M]

X-COORDINATE OF ORIGIN OF GRID: 0 [M]

GRID SPACING IN X-DIRECTION: 10 [M]

NUMBER OF NODES IN X-DIRECTION: 20

Y-COORDINATE OF ORIGIN OF GRID: 0 [M]

GRID SPACING IN Y-DIRECTION: .10 [M]

NUMBER OF NODES IN Y-DIRECTION: 10

***** RESULTS *****

CONCENTRATION IN [MOL/L]

----- RESULTS CONTINUED ----- PLUME - PAGE :

X-> 60 70 80 90 100 110

Y

0	0.2306E-14	0.2066E-17	0.4101E-21	0.0000E+00	0.0000E+00	0.0000E+00
10	0.2425E-15	0.2172E-18	0.4312E-22	0.0000E+00	0.0000E+00	0.0000E+00
20	0.2857E-18	0.2559E-21	0.5080E-25	0.0000E+00	0.0000E+00	0.0000E+00
30	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
40	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
50	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
60	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
70	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
80	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
90	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

X-> 120 130 140 150 160 170

Y

0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
10	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
20	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
30	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
40	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
50	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
60	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
70	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
80	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
90	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

X-> 180 190

Y

0	0.0000E+00	0.0000E+00
10	0.0000E+00	0.0000E+00
20	0.0000E+00	0.0000E+00
30	0.0000E+00	0.0000E+00
40	0.0000E+00	0.0000E+00
50	0.0000E+00	0.0000E+00
60	0.0000E+00	0.0000E+00
70	0.0000E+00	0.0000E+00
80	0.0000E+00	0.0000E+00
90	0.0000E+00	0.0000E+00

CALCULATION OF CONCENTRATION VALUES FOR A SINGLE RADIOACTIVE OR NON-RADIOACTIVE TRACER IN A HOMOGENEOUS TWO- OR THREE-DIMENSIONAL GROUND WATER SYSTEM WITH UNI-LATERAL REGIONAL FLOW

Cs137 9125 days 1CI south

***** INPUT DATA *****

AVERAGE INTERSTITIAL VELOCITY: .676 [M/DAY]

HALF LIFE TIME: 30.1 YRS
RETARDATION FACTOR: 1000

AQUIFER THICKNESS: 30.5 [M]
EFFECTIVE POROSITY: .3
LENGTH OF LINE SOURCE: 1 [M]

DISPERSIVITY IN X-DIRECTION: .6 [M]
DISPERSIVITY IN Y-DIRECTION: .2 [M]
DISPERSIVITY IN Z-DIRECTION: .2 [M]

VERTICAL POSITION OF SOURCE BENEATH SURFACE: 0 [M]

----- SOURCE STRENGTH TABLE -----

NUMBER OF DATA PAIRS IN TABLE: 3

T(1)= 0	SEC	W(1)= 1	CI/SEC
T(2)= 1	SEC	W(2)= 1	CI/SEC
T(3)= 1.0001	SEC	W(3)= 0	CI/SEC

AREA UNDER PULSE IN GRAPH (= TOTAL MASS RELEASE): 1.00005 CURIES
TIME CENTROID: 5.787326E-06 DAYS (= .500025 SEC)

NUMBER OF DIVISIONS IN SOURCE PULSE · 10

CALCULATION TIME: 9125 DAY

----- GRID DATA -----

DEPTH OF (HORIZONTAL) GRID BENEATH SURFACE (= Z-POSITION): 3 [M]

X-COORDINATE OF ORIGIN OF GRID: 0 [M]
GRID SPACING IN X-DIRECTION: 10 [MM]
NUMBER OF NODES IN X-DIRECTION: 20

Y-COORDINATE OF ORIGIN OF GRID: 0 [M]
GRID SPACING IN Y-DIRECTION: 10 [M]
NUMBER OF NODES IN Y-DIRECTION: 10

RESULTS

----- CONCENTRATION IN EC/L -----

X- > 0 10 20 30 40 50

```

Y
0   -.10000E+01 0.2010E-08 0.1323E-13 0.0000E+00 0.0000E+00 0.0000E+00
10  0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
20  0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
30  0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
40  0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
50  0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
60  0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
70  0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
80  0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
90  0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00

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----- RESULTS CONTINUED ----- PLUME - PAGE

X-> 60 70 80 90 100 110

Y

0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
10	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
20	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
30	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
40	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
50	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
60	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
70	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
80	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
90	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

X-> 120 130 140 150 160 170

Y

0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
10	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
20	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
30	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
40	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
50	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
60	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
70	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
80	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
90	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

X-> 180 190

Y

0	0.0000E+00	0.0000E+00
10	0.0000E+00	0.0000E+00
20	0.0000E+00	0.0000E+00
30	0.0000E+00	0.0000E+00
40	0.0000E+00	0.0000E+00
50	0.0000E+00	0.0000E+00
60	0.0000E+00	0.0000E+00
70	0.0000E+00	0.0000E+00
80	0.0000E+00	0.0000E+00
90	0.0000E+00	0.0000E+00

CALCULATION OF CONCENTRATION VALUES FOR A SINGLE RADIOACTIVE OR NON-RADIOACTIVE TRACER IN A HOMOGENEOUS TWO- OR THREE-DIMENSIONAL GROUND WATER SYSTEM WITH UNI-LATERAL REGIONAL FLOW

Cs137 36500 days 1Ci west

to file 1/21/91

***** INPUT DATA *****

AVERAGE INTERSTITIAL VELOCITY: 2.02 [M/DAY]

HALF LIFE TIME: 30.1 YRS

RETARDATION FACTOR: 1000

AQUIFER THICKNESS: 30.5 [M]

EFFECTIVE POROSITY: .3

LENGTH OF LINE SOURCE: 1 [M]

DISPERSIVITY IN X-DIRECTION: 7.3 [M]

DISPERSIVITY IN Y-DIRECTION: 2.4 [M]

DISPERSIVITY IN Z-DIRECTION: 2.4 [M]

VERTICAL POSITION OF SOURCE BENEATH SURFACE: 0 [M]

----- SOURCE STRENGTH TABLE -----

NUMBER OF DATA PAIRS IN TABLE: 3

T(1)= 0	SEC	W(1)= 1	CI/SEC
T(2)= 1	SEC	W(2)= 1	CI/SEC
T(3)= 1.0001	SEC	W(3)= 0	CI/SEC

D.L. = .20 E -10

* Multiply by 10 for source strength of 10 Ci

AREA UNDER PULSE IN GRAPH (= TOTAL MASS RELEASE): 1.00005 CURIES
TIME CENTROID: 5.787326E-06 DAYS (= .500025 SEC)

NUMBER OF DIVISIONS IN SOURCE PULSE: 10

CALCULATION TIME: 36500 DAY

----- GRID DATA -----

DEPTH OF (HORIZONTAL) GRID BENEATH SURFACE (= Z-POSITION): 3 [M]

X-COORDINATE OF ORIGIN OF GRID: 0 [M]
GRID SPACING IN X-DIRECTION: 10 [M]
NUMBER OF NODES IN X-DIRECTION: 20

Y-COORDINATE OF ORIGIN OF GRID: 0 [M]
GRID SPACING IN Y-DIRECTION: 10 [M]
NUMBER OF NODES IN Y-DIRECTION: 10

***** RESULTS *****

----- CONCENTRATION IN [C1/L] -----

X->	0	10	20	30	40	50
Y						
0	-1.000E+01	0.5339E-12	0.9212E-12	0.1449E-11	0.2076E-11	0.2711E-11
10	0.2447E-12	0.4633E-12	0.7995E-12	0.1257E-11	0.1802E-11	0.2353E-11
20	0.1602E-12	0.3033E-12	0.5234E-12	0.8231E-12	0.1179E-11	0.1540E-11
30	0.7901E-13	0.1496E-12	0.2582E-12	0.4060E-12	0.5818E-12	0.7598E-12
40	0.2940E-13	0.5567E-13	0.9607E-13	0.1511E-12	0.2165E-12	0.2827E-12
50	0.8255E-14	0.1563E-13	0.2697E-13	0.4242E-13	0.6079E-13	0.7938E-13
60	0.1749E-14	0.3313E-14	0.5716E-14	0.8989E-14	0.1288E-13	0.1682E-13
70	0.2796E-15	0.5295E-15	0.9137E-15	0.1437E-14	0.2059E-14	0.2689E-14
80	0.3366E-16	0.6375E-16	0.1100E-15	0.1730E-15	0.2479E-15	0.3237E-15
90	0.2772E-17	0.5250E-17	0.9059E-17	0.1425E-16	0.2041E-16	0.2666E-16

X->	60	70	80	90	100	110
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Y

0	0.3226E-11	0.3499E-11	0.3458E-11	0.3114E-11	0.2556E-11	0.1911E-11
10	0.2800E-11	0.3036E-11	0.3001E-11	0.2703E-11	0.2218E-11	0.1659E-11
20	0.1833E-11	0.1988E-11	0.1965E-11	0.1769E-11	0.1452E-11	0.1086E-11
30	0.9042E-12	0.9806E-12	0.9691E-12	0.8728E-12	0.7163E-12	0.5357E-12
40	0.3364E-12	0.3649E-12	0.3606E-12	0.3247E-12	0.2665E-12	0.1993E-12
50	0.9447E-13	0.1024E-12	0.1012E-12	0.9118E-13	0.7483E-13	0.5597E-13
60	0.2002E-13	0.2171E-13	0.2146E-13	0.1932E-13	0.1586E-13	0.1186E-13
70	0.3200E-14	0.3470E-14	0.3429E-14	0.3089E-14	0.2535E-14	0.1896E-14
80	0.3852E-15	0.4178E-15	0.4129E-15	0.3719E-15	0.3052E-15	0.2282E-15
90	0.3173E-16	0.3441E-16	0.3400E-16	0.3062E-16	0.2513E-16	0.1880E-16

X->	120	130	140	150	160	170
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Y

0	0.1303E-11	0.8091E-12	0.4579E-12	0.2362E-12	0.1110E-12	0.4755E-13
10	0.1131E-11	0.7022E-12	0.3974E-12	0.2050E-12	0.9635E-13	0.4127E-13
20	0.7401E-12	0.4597E-12	0.2602E-12	0.1342E-12	0.6307E-13	0.2702E-13
30	0.3651E-12	0.2268E-12	0.1283E-12	0.6620E-13	0.3111E-13	0.1333E-13
40	0.1358E-12	0.8437E-13	0.4775E-13	0.2463E-13	0.1158E-13	0.4959E-14
50	0.3814E-13	0.2369E-13	0.1341E-13	0.6916E-14	0.3251E-14	0.1392E-14
60	0.8084E-14	0.5021E-14	0.2842E-14	0.1466E-14	0.6889E-15	0.2951E-15
70	0.1292E-14	0.8025E-15	0.4542E-15	0.2343E-15	0.1101E-15	0.4716E-16
80	0.1556E-15	0.9662E-16	0.5468E-16	0.2820E-16	0.1326E-16	0.5678E-17
90	0.1281E-16	0.7957E-17	0.4503E-17	0.2323E-17	0.1092E-17	0.4676E-18

X->	180	190
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Y

0	0.1856E-13	0.6602E-14
10	0.1611E-13	0.5730E-14
20	0.1055E-13	0.3751E-14
30	0.5202E-14	0.1850E-14
40	0.1936E-14	0.6885E-15
50	0.5435E-15	0.1933E-15
60	0.1152E-15	0.4097E-16
70	0.1841E-16	0.6548E-17
80	0.2216E-17	0.7884E-18
90	0.1825E-18	0.6492E-19

CALCULATION TIME: 36500 DAY

GRID DATA

DEPTH OF (HORIZONTAL) GRID BENEATH SURFACE (= Z-POSITION): 3 [EM]

X-COORDINATE OF ORIGIN OF GRID: 0 [M]

GRID SPACING IN X-DIRECTION: 20 [M]

NUMBER OF NODES IN X-DIRECTION: 20

Y-COORDINATE OF ORIGIN OF GRID: 0 [M]

GRID SPACING IN Y-DIRECTION: 20 [M]

NUMBER OF NODES IN Y-DIRECTION: 10

RESULTS

CONCENTRATION IN [Cl/L]

X->	120	140	160	180	200	220
Y						
0	0.1303E-11	0.4579E-12	0.1110E-12	0.1856E-13	0.2140E-14	0.1702E-15
20	0.7401E-12	0.2602E-12	0.6307E-13	0.1055E-13	0.1216E-14	0.9668E-16
40	0.1358E-12	0.4775E-13	0.1158E-13	0.1936E-14	0.2232E-15	0.1774E-16
60	0.8084E-14	0.2842E-14	0.6889E-15	0.1152E-15	0.1328E-16	0.1056E-17
80	0.1556E-15	0.5468E-16	0.1326E-16	0.2216E-17	0.2555E-18	0.2032E-19
100	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
120	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
140	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
160	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
180	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
X->	240	260	280	300	320	340
Y						
0	0.9331E-17	0.3529E-18	0.9203E-20	0.1655E-21	0.2053E-23	0.0000E+00
20	0.5301E-17	0.2005E-18	0.5229E-20	0.9404E-22	0.1166E-23	0.0000E+00
40	0.9730E-18	0.3680E-19	0.9597E-21	0.1726E-22	0.2141E-24	0.0000E+00
60	0.5790E-19	0.2190E-20	0.5710E-22	0.1027E-23	0.1274E-25	0.0000E+00
80	0.1114E-20	0.4214E-22	0.1099E-23	0.1976E-25	0.2452E-27	0.0000E+00
100	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
120	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
140	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
160	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
180	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
X->	360	380				
Y						
0	0.0000E+00	0.0000E+00				
20	0.0000E+00	0.0000E+00				
40	0.0000E+00	0.0000E+00				
60	0.0000E+00	0.0000E+00				
80	0.0000E+00	0.0000E+00				
100	0.0000E+00	0.0000E+00				
120	0.0000E+00	0.0000E+00				
140	0.0000E+00	0.0000E+00				
160	0.0000E+00	0.0000E+00				
180	0.0000E+00	0.0000E+00				

***** PLUME ***** PAGE

CALCULATION OF CONCENTRATION VALUES FOR A SINGLE RADIOACTIVE OR NON-RADIOACTIVE TRACER IN A HOMOGENEOUS TWO- OR THREE-DIMENSIONAL GROUND WATER SYSTEM WITH UNI-LATERAL REGIONAL FLOW

Cs137 36500 days 1CI south

to AW 1/21/91

***** INPUT DATA *****

AVERAGE INTERSTITIAL VELOCITY: .676 [M/DAY]

HALF LIFE TIME: 30.1 YRS

RETARDATION FACTOR: 1000

AQUIFER THICKNESS: 30.5 [M]

EFFECTIVE POROSITY: .3

LENGTH OF LINE SOURCE: 1 [M]

DISPERSIVITY IN X-DIRECTION: 2.6 [M]

DISPERSIVITY IN Y-DIRECTION: .87 [M]

DISPERSIVITY IN Z-DIRECTION: .87 [M]

VERTICAL POSITION OF SOURCE BENEATH SURFACE: 0 [M]

----- SOURCE STRENGTH TABLE -----

NUMBER OF DATA PAIRS IN TABLE: 3

T(1)= 0	SEC	W(1)= 1	C1/SEC
T(2)= 1	SEC	W(2)= 1	C1/SEC
T(3)= 1.0001	SEC	W(3)= 0	C1/SEC

----- INPUT DATA -CONTINUED- ----- PLUME - PAGE 2

AREA UNDER PULSE IN GRAPH (= TOTAL MASS RELEASE): 1.00005 CURIES
TIME CENTROID: 5.787326E-06 DAYS (= .500025 SEC)

NUMBER OF DIVISIONS IN SOURCE PULSE: 10

CALCULATION TIME: 36500 DAY

GRID DATA

DEPTH OF (HORIZONTAL) GRID BENEATH SURFACE (= Z-POSITION): 3 [M]

X-COORDINATE OF ORIGIN OF GRID: 0 [M]
GRID SPACING IN X-DIRECTION: 10 [M]
NUMBER OF NODES IN X-DIRECTION: 20

Y-COORDINATE OF ORIGIN OF GRID: 0 [M]
GRID SPACING IN Y-DIRECTION: 10 [M]
NUMBER OF NODES IN Y-DIRECTION: 10

RESULTS

CONCENTRATION IN [C1/L]

----- RESULTS CONTINUED ----- PLUME - PAGE 1

X-> 60 70 80 90 100 110

Y

0	0.5850E-12	0.2524E-13	0.4997E-15	0.4536E-17	0.1889E-19	0.3609E-22
10	0.1828E-12	0.7890E-14	0.1562E-15	0.1418E-17	0.5905E-20	0.1128E-22
20	0.5608E-14	0.2420E-15	0.4790E-17	0.4349E-19	0.1811E-21	0.3460E-24
30	0.1670E-16	0.7295E-18	0.1444E-19	0.1311E-21	0.5459E-24	0.1043E-26
40	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
50	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
60	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
70	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
80	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
90	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

X-> 120 130 140 150 160 170

Y

0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
10	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
20	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
30	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
40	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
50	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
60	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
70	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
80	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
90	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

X-> 180 190

Y

0	0.0000E+00	0.0000E+00
10	0.0000E+00	0.0000E+00
20	0.0000E+00	0.0000E+00
30	0.0000E+00	0.0000E+00
40	0.0000E+00	0.0000E+00
50	0.0000E+00	0.0000E+00
60	0.0000E+00	0.0000E+00
70	0.0000E+00	0.0000E+00
80	0.0000E+00	0.0000E+00
90	0.0000E+00	0.0000E+00

APPENDIX A-3

CESIUM-137
Dy = 1/10(Dx)

***** PLUME ***** PAGE

CALCULATION OF CONCENTRATION VALUES FOR A SINGLE RADIOACTIVE OR NON-RADIOACTIVE TRACER IN A HOMOGENEOUS TWO- OR THREE-DIMENSIONAL GROUND WATER SYSTEM WITH UNI-LATERAL REGIONAL FLOW

Cs137 36500 d 1 C1 south

to AK Singh 1/21/91

***** INPUT DATA *****

AVERAGE INTERSTITIAL VELOCITY: .676 [M/DAY]

HALF LIFE TIME: 30.1 YRS

RETARDATION FACTOR: 1000

AQUIFER THICKNESS: 30.5 [M]

EFFECTIVE POROSITY: .3

LENGTH OF LINE SOURCE: 1 [M]

DISPERSIVITY IN X-DIRECTION: 2.6 [M]

DISPERSIVITY IN Y-DIRECTION: .26 [M]

DISPERSIVITY IN Z-DIRECTION: .26 [M]

VERTICAL POSITION OF SOURCE BENEATH SURFACE: 0 [M]

----- SOURCE STRENGTH TABLE -----

NUMBER OF DATA PAIRS IN TABLE: 3

T(1)= 0	SEC	W(1)= 1	C1/SEC
T(2)= 1	SEC	W(2)= 1	C1/SEC
T(3)= 1.0001	SEC	W(3)= 0	C1/SEC

----- INPUT DATA -CONTINUED- ----- PLUME - PAGE

AREA UNDER PULSE IN GRAPH (= TOTAL MASS RELEASE): 1.00005 CURIES
TIME CENTROID: 5.787326E-06 DAYS (= .500025 SEC)

NUMBER OF DIVISIONS IN SOURCE PULSE: 10

CALCULATION TIME: 36500 DAY

----- GRID DATA -----
DEPTH OF (HORIZONTAL) GRID BENEATH SURFACE (= Z-POSITION): 3 [M]

X-COORDINATE OF ORIGIN OF GRID: 0 [M]
GRID SPACING IN X-DIRECTION: 10 [M]
NUMBER OF NODES IN X-DIRECTION: 20

Y-COORDINATE OF ORIGIN OF GRID: 0 [M]
GRID SPACING IN Y-DIRECTION: 10 [M]
NUMBER OF NODES IN Y-DIRECTION: 10

***** RESULTS *****

----- CONCENTRATION IN [M/L]

----- RESULTS CONTINUED ----- PLUME - PAGE

X-> 60 70 80 90 100 110

Y

0	0.1527E-11	0.6589E-13	0.1304E-14	0.1184E-16	0.4931E-19	0.9420E-22
10	0.3183E-13	0.1373E-14	0.2716E-16	0.2468E-18	0.1028E-20	0.1963E-23
20	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
30	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
40	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
50	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
60	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
70	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
80	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
90	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

X-> 120 130 140 150 160 170

Y

0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
10	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
20	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
30	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
40	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
50	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
60	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
70	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
80	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
90	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

X-> 180 190

Y

0	0.0000E+00	0.0000E+00
10	0.0000E+00	0.0000E+00
20	0.0000E+00	0.0000E+00
30	0.0000E+00	0.0000E+00
40	0.0000E+00	0.0000E+00
50	0.0000E+00	0.0000E+00
60	0.0000E+00	0.0000E+00
70	0.0000E+00	0.0000E+00
80	0.0000E+00	0.0000E+00
90	0.0000E+00	0.0000E+00

CALCULATION OF CONCENTRATION VALUES FOR A SINGLE RADIOACTIVE OR NON-RADIOACTIVE TRACER IN A HOMOGENEOUS TWO- OR THREE-DIMENSIONAL GROUND WATER SYSTEM WITH UNI-LATERAL REGIONAL FLOW

Cs137 36500 d 1C1 west

to AK Singh 1/21/91.

***** INPUT DATA *****

AVERAGE INTERSTITIAL VELOCITY: 2.02 [M/DAY]

HALF LIFE TIME: 30.1 YRS

RETARDATION FACTOR: 1000

AQUIFER THICKNESS: 30.5 [M]

EFFECTIVE POROSITY: .3

LENGTH OF LINE SOURCE: 1 [M]

DISPERSIVITY IN X-DIRECTION: 7.3 [M]

DISPERSIVITY IN Y-DIRECTION: .73 [M]

DISPERSIVITY IN Z-DIRECTION: .73 [M]

VERTICAL POSITION OF SOURCE BENEATH SURFACE: 0 [M]

----- SOURCE STRENGTH TABLE -----

NUMBER OF DATA PAIRS IN TABLE: 3

T(1)= 0	SEC	W(1)= 1	CI/SEC
T(2)= 1	SEC	W(2)= 1	CI/SEC
T(3)= 1.0001	SEC	W(3)= 0	CI/SEC

----- INPUT DATA -CONTINUED- ----- PLUME - PAGE

AREA UNDER PULSE IN GRAPH (= TOTAL MASS RELEASE): 1.00005 CURIES
TIME CENTROID: 5.787326E-06 DAYS (= .500025 SEC)

NUMBER OF DIVISIONS IN SOURCE PULSE: 10

CALCULATION TIME: 36500 DAY

GRID DATA

DEPTH OF (HORIZONTAL) GRID BENEATH SURFACE (= Z-POSITION): 3 [M]

X-COORDINATE OF ORIGIN OF GRID: 0 [M]
GRID SPACING IN X-DIRECTION: 10 [M]
NUMBER OF NODES IN X-DIRECTION: 20

Y-COORDINATE OF ORIGIN OF GRID: 0 [M]
GRID SPACING IN Y-DIRECTION: 10 [M]
NUMBER OF NODES IN Y-DIRECTION: 10

RESULTS ***

----- CONCENTRATION IN EC/L -----

----- RESULTS CONTINUED ----- PLUME - PAGE

X-> 60 70 80 90 100 110

Y

0	0.1018E-10	0.1104E-10	0.1091E-10	0.9825E-11	0.8063E-11	0.6030E-11
10	0.6398E-11	0.6938E-11	0.6857E-11	0.6175E-11	0.5068E-11	0.3790E-11
20	0.1589E-11	0.1723E-11	0.1703E-11	0.1534E-11	0.1259E-11	0.9413E-12
30	0.1564E-12	0.1696E-12	0.1676E-12	0.1509E-12	0.1239E-12	0.9264E-13
40	0.6098E-14	0.6613E-14	0.6536E-14	0.5886E-14	0.4831E-14	0.3613E-14
50	0.9467E-16	0.1027E-15	0.1015E-15	0.9138E-16	0.7499E-16	0.5609E-16
60	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
70	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
80	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
90	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

X-> 120 130 140 150 160 170

Y

0	0.4110E-11	0.2553E-11	0.1445E-11	0.7452E-12	0.3503E-12	0.1500E-12
10	0.2583E-11	0.1604E-11	0.9081E-12	0.4684E-12	0.2201E-12	0.9429E-13
20	0.6416E-12	0.3985E-12	0.2255E-12	0.1163E-12	0.5467E-13	0.2342E-13
30	0.6314E-13	0.3921E-13	0.2220E-13	0.1145E-13	0.5381E-14	0.2305E-14
40	0.2462E-14	0.1529E-14	0.8656E-15	0.4465E-15	0.2098E-15	0.8988E-16
50	0.3823E-16	0.2374E-16	0.1344E-16	0.6931E-17	0.3258E-17	0.1395E-17
60	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
70	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
80	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
90	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

X-> 180 190

Y

0	0.5856E-13	0.2083E-13
10	0.3681E-13	0.1309E-13
20	0.9141E-14	0.3251E-14
30	0.8996E-15	0.3200E-15
40	0.3508E-16	0.1248E-16
50	0.5446E-18	0.1937E-18
60	0.0000E+00	0.0000E+00
70	0.0000E+00	0.0000E+00
80	0.0000E+00	0.0000E+00
90	0.0000E+00	0.0000E+00

DEPTH OF (HORIZONTAL) GRID BENEFATH SURFACE (= Z-POSITION): 3 [M]

X-COORDINATE OF ORIGIN OF GRID: 0 [M] GRID SPACING IN X-DIRECTION: 20 [CM]
NUMBER OF NODES IN X-DIRECTION: 20

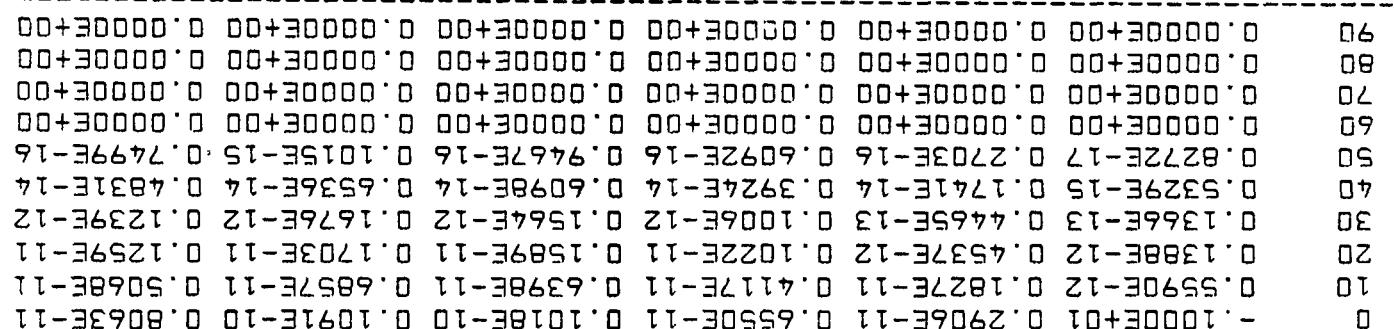
Y-COORDINATE OF ORIGIN OF GRID: 0 [M] GRID SPACING IN Y-DIRECTION: 10 [CM]
NUMBER OF NODES IN Y-DIRECTION: 10

***** RESULTS *****

----- CONCENTRATION IN [C1/L] -----

----- 100 80 60 40 20 0 X-->

y



----- PLUME - PAGE -----

CALCULATION TIME: 36500 DAY

----- RESULTS CONTINUED ----- PLUME - PAGE

X-> 120 140 160 180 200 220

Y

0	0.4110E-11	0.1445E-11	0.3503E-12	0.5856E-13	0.6752E-14	0.5369E-15
10	0.2583E-11	0.9081E-12	0.2201E-12	0.3681E-13	0.4244E-14	0.3374E-15
20	0.6416E-12	0.2255E-12	0.5467E-13	0.9141E-14	0.1054E-14	0.8380E-16
30	0.6314E-13	0.2220E-13	0.5381E-14	0.8996E-15	0.1037E-15	0.8247E-17
40	0.2462E-14	0.8656E-15	0.2098E-15	0.3508E-16	0.4045E-17	0.3216E-18
50	0.3823E-16	0.1344E-16	0.3258E-17	0.5446E-18	0.6279E-19	0.4993E-20
60	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
70	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
80	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
90	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

X-> 240 260 280 300 320 340

Y

0	0.2944E-16	0.1113E-17	0.2903E-19	0.5222E-21	0.6477E-23	0.0000E+00
10	0.1850E-16	0.6997E-18	0.1825E-19	0.3282E-21	0.4071E-23	0.0000E+00
20	0.4595E-17	0.1738E-18	0.4532E-20	0.8152E-22	0.1011E-23	0.0000E+00
30	0.4522E-18	0.1710E-19	0.4460E-21	0.8022E-23	0.9950E-25	0.0000E+00
40	0.1764E-19	0.6670E-21	0.1739E-22	0.3129E-24	0.3881E-26	0.0000E+00
50	0.2738E-21	0.1035E-22	0.2700E-24	0.4857E-26	0.6024E-28	0.0000E+00
60	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
70	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
80	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
90	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

X-> 360 380

Y

0	0.0000E+00	0.0000E+00
10	0.0000E+00	0.0000E+00
20	0.0000E+00	0.0000E+00
30	0.0000E+00	0.0000E+00
40	0.0000E+00	0.0000E+00
50	0.0000E+00	0.0000E+00
60	0.0000E+00	0.0000E+00
70	0.0000E+00	0.0000E+00
80	0.0000E+00	0.0000E+00
90	0.0000E+00	0.0000E+00

APPENDIX A-4
URANIUM-234/238
10 YEARS

CALCULATION OF CONCENTRATION VALUES FOR A SINGLE RADIOACTIVE OR NON-RADIOACTIVE TRACER IN A HOMOGENEOUS TWO- OR THREE-DIMENSIONAL GROUND WATER SYSTEM WITH UNI-LATERAL REGIONAL FLOW

U 234/238 3650 d .2 CI south

***** INPUT DATA *****

AVERAGE INTERSTITIAL VELOCITY: .676 [M/DAY]

HALF LIFE TIME: 1E+09 YRS

RETARDATION FACTOR: 151

AQUIFER THICKNESS: 30.5 [M]

EFFECTIVE POROSITY: .3

LENGTH OF LINE SOURCE: 1 [M]

DISPERSIVITY IN X-DIRECTION: 1.6 [M]

DISPERSIVITY IN Y-DIRECTION: .5 [M]

DISPERSIVITY IN Z-DIRECTION: .5 [M]

VERTICAL POSITION OF SOURCE BENEATH SURFACE: 0 [M]

----- SOURCE STRENGTH TABLE -----

NUMBER OF DATA PAIRS IN TABLE: 3

T(1)= 0	SEC	W(1)= .2	CI/SEC
T(2)= 1	SEC	W(2)= .2	CI/SEC
T(3)= 1.0001	SEC	W(3)= 0	CI/SEC

INPUT DATA -CONTINUED- ----- **PLUME - PAGE 2**

AREA UNDER PULSE IN GRAPH (= TOTAL MASS RELEASE): .20001 CURIES
TIME CENTROID: 5.787326E-06 DAYS (= .500025 SEC)

NUMBER OF DIVISIONS IN SOURCE PULSE: 10

CALCULATION TIME: 3650 DAY

GRID DATA

DEPTH OF (HORIZONTAL) GRID BENEATH SURFACE (= Z-POSITION): 3 [M]

X-COORDINATE OF ORIGIN OF GRID: 0 [M]
GRID SPACING IN X-DIRECTION: 10 [M]
NUMBER OF NODES IN X-DIRECTION: 20

Y-COORDINATE OF ORIGIN OF GRID: 0 [M]
GRID SPACING IN Y-DIRECTION: 10 [M]
NUMBER OF NODES IN Y-DIRECTION: 10

RESULTS

CONCENTRATION IN [CI/L]

x- \rightarrow 0 10 20 30 40 50

Y

X->	60	70	80	90	100	110
Y						
0	0.4217E-16	0.3833E-20	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
10	0.2009E-17	0.1826E-21	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
20	0.2170E-21	0.1972E-25	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
30	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
40	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
50	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
60	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
70	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
80	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
90	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

X->	120	130	140	150	160	170
Y						
0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
10	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
20	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
30	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
40	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
50	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
60	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
70	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
80	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
90	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

X->	180	190
Y		
0	0.0000E+00	0.0000E+00
10	0.0000E+00	0.0000E+00
20	0.0000E+00	0.0000E+00
30	0.0000E+00	0.0000E+00
40	0.0000E+00	0.0000E+00
50	0.0000E+00	0.0000E+00
60	0.0000E+00	0.0000E+00
70	0.0000E+00	0.0000E+00
80	0.0000E+00	0.0000E+00
90	0.0000E+00	0.0000E+00

***** PLUME ***** PAGE 1

CALCULATION OF CONCENTRATION VALUES FOR A SINGLE RADIOACTIVE
OR NON-RADIOACTIVE TRACER IN A HOMOGENEOUS TWO- OR THREE-
DIMENSIONAL GROUND WATER SYSTEM WITH UNI-LATERAL REGIONAL FLOW

U234/238 .2 CI west

***** INPUT DATA *****

AVERAGE INTERSTITIAL VELOCITY: 2.02 [M/DAY]

HALF LIFE TIME: 1E+09 YRS

RETARDATION FACTOR: 151

AQUIFER THICKNESS: 30.5 [M]

EFFECTIVE POROSITY: .3

LENGTH OF LINE SOURCE: 1 [M]

DISPERSIVITY IN X-DIRECTION: 5 [M]

DISPERSIVITY IN Y-DIRECTION: 1.6 [M]

DISPERSIVITY IN Z-DIRECTION: 1.6 [M]

VERTICAL POSITION OF SOURCE BENEATH SURFACE: 0 [M]

----- SOURCE STRENGTH TABLE -----

NUMBER OF DATA PAIRS IN TABLE: 3

T(1)= 0	SEC	W(1)= .2	CI/SEC
T(2)= 1	SEC	W(2)= .2	CI/SEC
T(3)= 1.0001	SEC	W(3)= 0	CI/SEC

INPUT DATA -CONTINUED- ----- **PLUME - PAGE 2**

AREA UNDER PULSE IN GRAPH (= TOTAL MASS RELEASE): .20001 CURIOS
TIME CENTROID: 5.787326E-06 DAYS (= .500025 SEC)

NUMBER OF DIVISIONS IN SOURCE PULSE: 10

CALCULATION TIME: 3650 DAY

GRID DATA

DEPTH OF (HORIZONTAL) GRID BENEATH SURFACE (= Z-POSITION): 3 [M]

X-COORDINATE OF ORIGIN OF GRID: 0 [M]
GRID SPACING IN X-DIRECTION: 10 [M]
NUMBER OF NODES IN X-DIRECTION: 20

Y-COORDINATE OF ORIGIN OF GRID: 0 [M]
GRID SPACING IN Y-DIRECTION: 10 [M]
NUMBER OF NODES IN Y-DIRECTION: 10

RESULTS

CONCENTRATION IN [CI/L]

x-> 0 10 20 30 40 50

Y

X->	60	70	80	90	100	110
Y						
0	0.1343E-09	0.9640E-10	0.5640E-10	0.2689E-10	0.1044E-10	0.3306E-11
10	0.9748E-10	0.7000E-10	0.4095E-10	0.1952E-10	0.7584E-11	0.2400E-11
20	0.3733E-10	0.2680E-10	0.1568E-10	0.7476E-11	0.2904E-11	0.9191E-12
30	0.7546E-11	0.5418E-11	0.3170E-11	0.1511E-11	0.5871E-12	0.1858E-12
40	0.8067E-12	0.5793E-12	0.3389E-12	0.1616E-12	0.6276E-13	0.1986E-13
50	0.4563E-13	0.3276E-13	0.1917E-13	0.9138E-14	0.3550E-14	0.1123E-14
60	0.1379E-14	0.9900E-15	0.5793E-15	0.2761E-15	0.1073E-15	0.3395E-16
70	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
80	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
90	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

X->	120	130	140	150	160	170
Y						
0	0.8525E-12	0.1791E-12	0.3067E-13	0.4279E-14	0.4864E-15	0.4505E-16
10	0.6190E-12	0.1301E-12	0.2227E-13	0.3107E-14	0.3532E-15	0.3271E-16
20	0.2370E-12	0.4981E-13	0.8528E-14	0.1190E-14	0.1352E-15	0.1253E-16
30	0.4792E-13	0.1007E-13	0.1724E-14	0.2405E-15	0.2734E-16	0.2532E-17
40	0.5123E-14	0.1076E-14	0.1843E-15	0.2571E-16	0.2923E-17	0.2707E-18
50	0.2897E-15	0.6088E-16	0.1042E-16	0.1454E-17	0.1653E-18	0.1531E-19
60	0.8756E-17	0.1840E-17	0.3150E-18	0.4395E-19	0.4996E-20	0.4627E-21
70	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
80	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
90	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

X->	180	190
Y		
0	0.3400E-17	0.2091E-18
10	0.2469E-17	0.1518E-18
20	0.9454E-18	0.5813E-19
30	0.1911E-18	0.1175E-19
40	0.2043E-19	0.1256E-20
50	0.1156E-20	0.7106E-22
60	0.3492E-22	0.2147E-23
70	0.0000E+00	0.0000E+00
80	0.0000E+00	0.0000E+00
90	0.0000E+00	0.0000E+00

APPENDIX A-5
URANIUM-234/238
25 YEARS

CALCULATION OF CONCENTRATION VALUES FOR A SINGLE RADIOACTIVE OR NON-RADIOACTIVE TRACER IN A HOMOGENEOUS TWO- OR THREE-DIMENSIONAL GROUND WATER SYSTEM WITH UNI-LATERAL REGIONAL FLOW

U 234/238 9125 d .2 CI south

***** INPUT DATA *****

AVERAGE INTERSTITIAL VELOCITY: .676 [M/DAY]

HALF LIFE TIME: 1E+09 YRS

RETARDATION FACTOR: 151

AQUIFER THICKNESS: 30.5 [M]

EFFECTIVE POROSITY: .3

LENGTH OF LINE SOURCE: 1 [M]

DISPERSIVITY IN X-DIRECTION: 4 [M]

DISPERSIVITY IN Y-DIRECTION: 1.3 [M]

DISPERSIVITY IN Z-DIRECTION: 1.3 [M]

VERTICAL POSITION OF SOURCE BENEATH SURFACE: 0 [M]

----- SOURCE STRENGTH TABLE -----

NUMBER OF DATA PAIRS IN TABLE: 3

T(1)= 0	SEC	W(1)= .2	CI/SEC
T(2)= 1	SEC	W(2)= .2	CI/SEC
T(3)= 1.0001	SEC	W(3)= 0	CI/SEC

INPUT DATA -CONTINUED- ----- **PLUME - PAGE 2**

AREA UNDER PULSE IN GRAPH (= TOTAL MASS RELEASE): .20001 CURIOS
TIME CENTROID: 5.787326E-06 DAYS (= .500025 SEC)

NUMBER OF DIVISIONS IN SOURCE PULSE: 10

CALCULATION TIME: 9125 DAY

GRID DATA

DEPTH OF (HORIZONTAL) GRID BENEATH SURFACE (= Z-POSITION): 3 [M]

X-COORDINATE OF ORIGIN OF GRID: 0 [M]
GRID SPACING IN X-DIRECTION: 10 [M]
NUMBER OF NODES IN X-DIRECTION: 20

Y-COORDINATE OF ORIGIN OF GRID: 0 [M]
GRID SPACING IN Y-DIRECTION: 10 [M]
NUMBER OF NODES IN Y-DIRECTION: 10

RESULTS

CONCENTRATION IN [CI/L]

x- \rightarrow 0 10 20 30 40 50

Y

X->	60	70	80	90	100	110
Y						
0	0.1544E-09	0.7375E-10	0.2594E-10	0.6718E-11	0.1281E-11	0.1800E-12
10	0.9644E-10	0.4606E-10	0.1620E-10	0.4196E-11	0.8003E-12	0.1124E-12
20	0.2351E-10	0.1123E-10	0.3949E-11	0.1023E-11	0.1951E-12	0.2740E-13
30	0.2242E-11	0.1071E-11	0.3767E-12	0.9755E-13	0.1861E-13	0.2613E-14
40	0.8380E-13	0.4003E-13	0.1408E-13	0.3646E-14	0.6954E-15	0.9768E-16
50	0.1308E-14	0.6245E-15	0.2197E-15	0.5689E-16	0.1085E-16	0.1524E-17
60	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
70	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
80	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
90	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

X->	120	130	140	150	160	170
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Y						
0	0.1861E-13	0.1418E-14	0.7951E-16	0.3284E-17	0.9987E-19	0.2237E-20
10	0.1163E-13	0.8854E-15	0.4966E-16	0.2051E-17	0.6238E-19	0.1397E-20
20	0.2834E-14	0.2158E-15	0.1210E-16	0.4999E-18	0.1520E-19	0.3405E-21
30	0.2703E-15	0.2059E-16	0.1155E-17	0.4769E-19	0.1450E-20	0.3248E-22
40	0.1010E-16	0.7694E-18	0.4315E-19	0.1782E-20	0.5421E-22	0.1214E-23
50	0.1576E-18	0.1201E-19	0.6733E-21	0.2781E-22	0.8458E-24	0.1894E-25
60	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
70	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
80	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
90	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

X->	180	190
-----	-----	-----

Y		
0	0.3689E-22	0.4481E-24
10	0.2304E-22	0.2799E-24
20	0.5616E-23	0.6821E-25
30	0.5357E-24	0.6507E-26
40	0.2002E-25	0.2432E-27
50	0.3124E-27	0.3795E-29
60	0.0000E+00	0.0000E+00
70	0.0000E+00	0.0000E+00
80	0.0000E+00	0.0000E+00
90	0.0000E+00	0.0000E+00

CALCULATION OF CONCENTRATION VALUES FOR A SINGLE RADIOACTIVE OR NON-RADIOACTIVE TRACER IN A HOMOGENEOUS TWO- OR THREE-DIMENSIONAL GROUND WATER SYSTEM WITH UNI-LATERAL REGIONAL FLOW

U 234/238 9125 d .2 CI west

***** INPUT DATA *****

AVERAGE INTERSTITIAL VELOCITY: 2.02 [M/DAY]

HALF LIFE TIME: 1E+09 YRS

RETARDATION FACTOR: 151

AQUIFER THICKNESS: 30.5 [M]

EFFECTIVE POROSITY: .3

LENGTH OF LINE SOURCE: 1 [M]

DISPERSIVITY IN X-DIRECTION: 12 [M]

DISPERSIVITY IN Y-DIRECTION: 4 [M]

DISPERSIVITY IN Z-DIRECTION: 4 [M]

VERTICAL POSITION OF SOURCE BENEATH SURFACE: 0 [M]

----- SOURCE STRENGTH TABLE -----

NUMBER OF DATA PAIRS IN TABLE: 3

T(1)= 0	SEC	W(1)= .2	CI/SEC
T(2)= 1	SEC	W(2)= .2	CI/SEC
T(3)= 1.0001	SEC	W(3)= 0	CI/SEC

AREA UNDER PULSE IN GRAPH (= TOTAL MASS RELEASE): .20001 CURIES
TIME CENTROID: 5.787326E-06 DAYS (= .500025 SEC)

NUMBER OF DIVISIONS IN SOURCE PULSE: 10

CALCULATION TIME: 9125 DAY

----- GRID DATA -----

DEPTH OF (HORIZONTAL) GRID BENEATH SURFACE (= Z-POSITION): 3 [M]

X-COORDINATE OF ORIGIN OF GRID: 0 [M]
GRID SPACING IN X-DIRECTION: 10 [M]
NUMBER OF NODES IN X-DIRECTION: 20

Y-COORDINATE OF ORIGIN OF GRID: 0 [M]
GRID SPACING IN Y-DIRECTION: 10 [M]
NUMBER OF NODES IN Y-DIRECTION: 10

***** RESULTS *****

----- CONCENTRATION IN [CI/L] -----

X-> 0 10 20 30 40 50

Y

0	-.1000E+01	0.1561E-11	0.2250E-11	0.3134E-11	0.4218E-11	0.5487E-11
10	0.9939E-12	0.1482E-11	0.2136E-11	0.2975E-11	0.4005E-11	0.5210E-11
20	0.8527E-12	0.1271E-11	0.1832E-11	0.2552E-11	0.3436E-11	0.4469E-11
30	0.6601E-12	0.9844E-12	0.1419E-11	0.1976E-11	0.2660E-11	0.3460E-11
40	0.4612E-12	0.6878E-12	0.9912E-12	0.1381E-11	0.1858E-11	0.2418E-11
50	0.2909E-12	0.4337E-12	0.6251E-12	0.8706E-12	0.1172E-11	0.1525E-11
60	0.1656E-12	0.2470E-12	0.3559E-12	0.4957E-12	0.6673E-12	0.8681E-12
70	0.8515E-13	0.1270E-12	0.1830E-12	0.2549E-12	0.3431E-12	0.4463E-12
80	0.3953E-13	0.5895E-13	0.8496E-13	0.1183E-12	0.1593E-12	0.2072E-12
90	0.1657E-13	0.2472E-13	0.3562E-13	0.4961E-13	0.6678E-13	0.8688E-13

X-> 60

70

80

90

100

110

Y

0	0.6899E-11	0.8383E-11	0.9844E-11	0.1117E-10	0.1225E-10	0.1299E-10
10	0.6550E-11	0.7959E-11	0.9346E-11	0.1061E-10	0.1163E-10	0.1233E-10
20	0.5619E-11	0.6828E-11	0.8018E-11	0.9099E-11	0.9980E-11	0.1058E-10
30	0.4350E-11	0.5286E-11	0.6207E-11	0.7045E-11	0.7727E-11	0.8190E-11
40	0.3039E-11	0.3693E-11	0.4337E-11	0.4922E-11	0.5398E-11	0.5722E-11
50	0.1917E-11	0.2329E-11	0.2735E-11	0.3104E-11	0.3404E-11	0.3609E-11
60	0.1091E-11	0.1326E-11	0.1557E-11	0.1767E-11	0.1938E-11	0.2055E-11
70	0.5611E-12	0.6818E-12	0.8007E-12	0.9087E-12	0.9966E-12	0.1056E-11
80	0.2605E-12	0.3165E-12	0.3717E-12	0.4219E-12	0.4627E-12	0.4904E-12
90	0.1092E-12	0.1327E-12	0.1558E-12	0.1769E-12	0.1940E-12	0.2056E-12

X-> 120

130

140

150

160

170

Y

0	0.1331E-10	0.1317E-10	0.1260E-10	0.1166E-10	0.1042E-10	0.8996E-11
10	0.1263E-10	0.1251E-10	0.1197E-10	0.1107E-10	0.9889E-11	0.8541E-11
20	0.1084E-10	0.1073E-10	0.1027E-10	0.9493E-11	0.8484E-11	0.7327E-11
30	0.8390E-11	0.8307E-11	0.7948E-11	0.7350E-11	0.6568E-11	0.5673E-11
40	0.5862E-11	0.5804E-11	0.5553E-11	0.5135E-11	0.4589E-11	0.3963E-11
50	0.3697E-11	0.3660E-11	0.3502E-11	0.3238E-11	0.2894E-11	0.2500E-11
60	0.2105E-11	0.2084E-11	0.1994E-11	0.1844E-11	0.1648E-11	0.1423E-11
70	0.1082E-11	0.1071E-11	0.1025E-11	0.9480E-12	0.8472E-12	0.7317E-12
80	0.5024E-12	0.4974E-12	0.4760E-12	0.4401E-12	0.3933E-12	0.3397E-12
90	0.2107E-12	0.2086E-12	0.1996E-12	0.1845E-12	0.1649E-12	0.1424E-12

X-> 180

190

Y

0	0.7509E-11	0.6058E-11
10	0.7130E-11	0.5751E-11
20	0.6116E-11	0.4934E-11
30	0.4735E-11	0.3820E-11
40	0.3308E-11	0.2669E-11
50	0.2086E-11	0.1683E-11
60	0.1188E-11	0.9583E-12
70	0.6108E-12	0.4927E-12
80	0.2836E-12	0.2288E-12
90	0.1189E-12	0.9591E-13

CALCULATION TIME: 9125 DAY

GRID DATA

DEPTH OF (HORIZONTAL) GRID BENEATH SURFACE (= Z-POSITION): 3 [M]

X-COORDINATE OF ORIGIN OF GRID: 0 [M]
GRID SPACING IN X-DIRECTION: 20 [M]
NUMBER OF NODES IN X-DIRECTION: 20

Y-COORDINATE OF ORIGIN OF GRID: 0 [M]
GRID SPACING IN Y-DIRECTION: 20 [M]
NUMBER OF NODES IN Y-DIRECTION: 10

RESULTS

CONCENTRATION IN [CI/L]

X->	120	140	160	180	200	220
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Y

0	0.1331E-10	0.1260E-10	0.1042E-10	0.7509E-11	0.4723E-11	0.2591E-11
20	0.1084E-10	0.1027E-10	0.8484E-11	0.6116E-11	0.3847E-11	0.2111E-11
40	0.5862E-11	0.5553E-11	0.4589E-11	0.3308E-11	0.2081E-11	0.1142E-11
60	0.2105E-11	0.1994E-11	0.1648E-11	0.1188E-11	0.7471E-12	0.4099E-12
80	0.5024E-12	0.4760E-12	0.3933E-12	0.2836E-12	0.1783E-12	0.9785E-13
100	0.7976E-13	0.7556E-13	0.6244E-13	0.4501E-13	0.2831E-13	0.1553E-13
120	0.8414E-14	0.7970E-14	0.6587E-14	0.4749E-14	0.2986E-14	0.1639E-14
140	0.5899E-15	0.5588E-15	0.4618E-15	0.3329E-15	0.2094E-15	0.1149E-15
160	0.3105E-16	0.2941E-16	0.2430E-16	0.1752E-16	0.1102E-16	0.6046E-17
180	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

X->	240	260	280	300	320	340
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Y

0	0.1240E-11	0.5179E-12	0.1886E-12	0.5995E-13	0.1662E-13	0.4019E-14
20	0.1010E-11	0.4218E-12	0.1536E-12	0.4883E-13	0.1354E-13	0.3273E-14
40	0.5464E-12	0.2282E-12	0.8311E-13	0.2641E-13	0.7321E-14	0.1771E-14
60	0.1962E-12	0.8193E-13	0.2984E-13	0.9483E-14	0.2629E-14	0.6358E-15
80	0.4683E-13	0.1956E-13	0.7123E-14	0.2264E-14	0.6275E-15	0.1518E-15
100	0.7435E-14	0.3104E-14	0.1131E-14	0.3593E-15	0.9962E-16	0.2409E-16
120	0.7843E-15	0.3275E-15	0.1193E-15	0.3791E-16	0.1051E-16	0.2541E-17
140	0.5499E-16	0.2296E-16	0.8363E-17	0.2658E-17	0.7368E-18	0.1782E-18
160	0.2894E-17	0.1208E-17	0.4402E-18	0.1399E-18	0.3878E-19	0.9378E-20
180	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

X->	360	380
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Y

0	0.8479E-15	0.1561E-15
20	0.6906E-15	0.1271E-15
40	0.3736E-15	0.6875E-16
60	0.1341E-15	0.2469E-16
80	0.3202E-16	0.5893E-17
100	0.5083E-17	0.9355E-18
120	0.5362E-18	0.9868E-19
140	0.3759E-19	0.6919E-20
160	0.1978E-20	0.3641E-21
180	0.0000E+00	0.0000E+00

APPENDIX B

DETECTION PROBABILITIES

Table B-1

Detection probabilities for tritium after 100 days, $D_y = (1/3) D_x$, source activity equals 0.3 Ci

Borehole/ Monitoring Well Number	Source = 0.3 Ci	Detection Probability
B1	0.0000	
B2	0.0000	
B3	0.0000	
B4	0.0000	
B5	0.0000	
B6	0.0000	
B7	0.0000	
B8	0.0000	
MW-1	0.0000	
MW-11	0.0000	
MW-8	0.0000	
MW-24	0.0000	
MW-10	0.0000	
MW-7	0.0000	
MW-6	0.0000	
MW-18	0.1100	
MW-23	0.0806	
MW-19	0.1026	
P(detection by at least one of the boreholes)	0.0000	
P(detection by at least one of the monitoring wells)	0.2657	

Note: activity (0,0) set equal to activity at (10,0).

Table B-2

Detection probabilities for Cs-137 after 100 years, source activity equals 10 Ci

Borehole/ Monitoring Well Number	$D_y = (1/3) D_x$ Detection Probability	$D_y = (1/10) D_x$ Detection Probability
B1	0.0244	0.0320
B2	0.0465	0.0596
B3	0.0484	0.0619
B4	0.0489	0.0629
B5	0.0380	0.0450
B6	0.0000	0.0000
B7	0.0000	0.0000
B8	0.0000	0.0000
MW-1	0.0000	0.0000
MW-11	0.0497	0.0642
MW-8	0.0000	0.0000
MW-24	0.0000	0.0000
MW-10	0.0000	0.0000
MW-7	0.0484	0.0150
MW-6	0.0000	0.0000
MW-18	0.0000	0.0000
MW-23	0.0000	0.0000
MW-19	0.0000	0.0000
P(detection by at least one of the boreholes)	0.1901	0.2358
P(detection by at least one of the monitoring wells)	0.0957	0.0782

Note: activity (0,0) set equal to activity at (10,0).

Table B-3Detection probabilities for U-234/238 at 0.2 Ci $D_y = (1/3) D_x$

Borehole/ Monitoring Well Number	Time = 10 yrs Detection Probability	Time = 25 yrs Detection Probability
B1	0.0519	0.0000
B2	0.0982	0.0000
B3	0.1037	0.0000
B4	0.1009	0.0000
B5	0.0658	0.0000
B6	0.0000	0.0000
B7	0.0000	0.0000
B8	0.0000	0.0000
MW-1	0.0313	0.0000
MW-11	0.1010	0.0000
MW-8	0.0000	0.0000
MW-24	0.0000	0.0000
MW-10	0.0000	0.0000
MW-7	0.0484	0.0484
MW-6	0.0000	0.0000
MW-18	0.0000	0.0321
MW-23	0.0000	0.0000
MW-19	0.0000	0.0283
P(detection by at least one of the boreholes)	0.3563	0.0000
P(detection by at least one of the monitoring wells)	0.1713	0.1050

Note: activity (0,0) set equal to activity at (10,0).

APPENDIX C

GLOSSARY

GLOSSARY

Activity -	The number of nuclear transformations occurring in a given quantity of material per unit time.
Cation Exchange - Capacity	The amount of cations that a unit mass of soil can adsorb from solution.
Curie (Ci) -	A unit of activity. One curie equals 3.7×10^{10} nuclear transformations per second. One picocurie equals 3.7×10^{-2} nuclear transformations per second.
Dispersion -	The spreading and mixing of chemical constituents in groundwater caused by diffusion and mixing due to microscopic variations in velocities within and between pores.
Half-life -	The time required for a radioactive substance to lose 50 percent (one-half) of its activity by decay.
Hydraulic - Conductivity	The rate of flow of water in gallons per day through a cross section of one square foot under a unit hydraulic gradient. In the SI System, the units are $\text{m}^3/\text{day}/\text{m}^2$ or m/day .
Hydraulic - Gradient	The rate of change in total head per unit of distance of flow in a given direction.
Isotopes -	Atomic nuclides having the same number of protons in their nuclei, and hence the same atomic number, but differing in the number of neutrons, therefore, in mass number. Different isotopes of the same element have almost identical chemical properties.
Isotropic -	Refers to a medium whose properties are the same in all directions.
Porosity -	The percentage of the bulk volume of a rock or soil that is occupied by interstices, whether isolated or connected.